DOCUMENT RESUME

ED 222 388 SE 039 493

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TITLE Sunny Side Up in Science.
INSTITUTION Seminole County Board of Public Instruction, Sanford, Fla.
SPONS AGENCY Florida State Dept. of Education, Tallahassee. Office of Environment Education.
PUB DATE Sep 81
NOTE 114p.; For related documents, see SE 039 494-496.

EDRS PRICE MF01/PC05 Plus Postage.
DESCRIPTORS *Biological Sciences; Conservation Education; Elementary School Science; Elementary Secondary Education; *Energy; Energy Conservation; Interdisciplinary Approach; *Physical Sciences; Science Activities; Science Education; *Science Experiments; *Secondary School Science; *Solar Radiation
IDENTIFIERS *Energy Education; Florida

ABSTRACT

Fossil fuels, upon which we now depend almost exclusively, are finite resources. Because the environmental problems inherent in large scale fossil fuel consumption are increasingly apparent, the reality of developing alternative energy sources must be faced. Solar energy is the obvious solution to the problem. It is a renewable, clean source that is infinite in supply. The purpose of this activity package is to enable students to discover the potential of the sun as an energy source. The activities, presented in eight units, are uniformly designed to incorporate the scientific method (posing a question and answering it through experimentation). The package is organized to include biological and physical science aspects of solar energy. The Seminole County science curriculum is covered by these two segments. The degree of difficulty varies in activities and in some instances a concept is presented twice, first in a simple format and then in a more complex framework. Activities/Experiments in the units focus on: nature of solar energy; solar collectors; concentrating solar energy; passive solar energy; solar stills; solar cells; and understanding bioenergy. The last unit contains additional energy activities. Materials needed, procedures, and questions are provided for each activity. (Author/JN)

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SUNNY SIDE UP IN SCIENCE

THE SCHOOL BOARD OF SEMINOLE COUNTY, FLORIDA

SE039493

SUNNY SIDE UP IN SCIENCE

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Sunny Side Up was partially supported by a 1980-81 Environmental Education Mini-grant from the Florida Department of Education.

September
1981

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ACKNOWLEDGEMENTS

Many people are responsible for Sunny Side Up. Seminole County teachers worked long and hard to produce the curriculum in Language Arts, Mathematics, Science, and Social Studies. Carol Gentry provided the abundance of excellent illustrations and Eileen Dunn supervised typing and retyping the manuscripts. But there are many others who helped. Dick Tillis and Jim Phillips from Florida's Office of Environmental Education provided the funding and made many valuable suggestions during the project. Rosalyn Tillis generously supplied an abundance of publications from the Governor's Energy Office.

We borrowed ideas, activities and even some illustrations from other energy education materials including:

Solar Energy Project developed for the U. S. Department of Energy by the New York State Education Department, Bureau of Science Education;

Solar Energy I and II from the American Museum of Science and Energy, Oak Ridge Associated Universities;

Energy and My Environment by Matt Brennan, published by the Florida's Governor's Energy Office, and;

Solar '80's by David LaHart which is published by the Florida Solar Energy Center. Copyrighted material was included only when proper permission could be obtained.

Sunny Side Up is symbolized by Sunny Solar, an all knowing critter who has not lost the common touch. Notice the bad tennis shoes! Professor, hard hat, adventurer or politician, Sunny is always helping us along the path to energy knowledge. We hope you enjoy Sunny while you are learning about energy.

David E. LaHart
Cape Canaveral

INTRODUCTION

The sun is the source of almost all the energy on earth. For the most part this phenomenon is indirect and therefore not readily recognized. Conversion of sunlight in green plants and burning of fossil fuels are examples of this indirect utilization of the sun's energy.

Fossil fuels, upon which we now depend almost exclusively, are finite resources. Additionally, the environmental problems inherent in large scale fossil fuel consumption are increasingly apparent. This is reflected in the massive amounts of carbon dioxide being pumped into the atmosphere and the production of acid rain. Eventually we must face reality and develop alternate energy sources. Solar is the <u>obvious</u> solution to this problem. It is a renewable, clean source that is infinite in supply. As educators, it is our responsibility to familiarize students with this concept.

The purpose of this activity package is to enable the students to discover the potential of the sun as an energy source. The activities are uniformly designed to incorporate the scientific method, i.e., posing a question and answering it through experimentation.

The package is organized to include biological and physical science aspects of Solar Energy. The Seminole County science curriculum (6th - EARTH; 7th - LIFE; 8th - PHYSICAL) is covered by these two segments. The degree of difficulty varies and in some instances one concept is presented twice. First in a simple format, next in a more complex framework.

UNIT I

THE NATURE OF SOLAR ENERGY

ACTIVITY 1

WHAT IS SOLAR ENERGY?

MATERIALS:

- Resource books on solar energy
- One thermometer with the bulb painted black
- One prism
- One spectroscope
- One light socket with a 300 watt standard incandescent bulb and a 300 watt infrared bulb
- One fluorescent light source
- One jar of water (each group must have a jar the same size.)

METHOD:

1. Direct sunlight through a prism onto a sheet of paper. Draw a labeled diagram to describe what you observe.
2. Use reference books to read about the visible spectrum. Next to your first diagram make another labeled diagram to show the visible spectrum shown in your reference book.
3. Point your spectroscope to the side of the sun and draw a labeled diagram of what you observe. NEVER LOOK DIRECTLY AT THE SUN EVEN THROUGH A SPECTROSCOPE. Point your spectroscope toward a fluorescent light and draw a labeled diagram of what you observe.
4. A) Place a black bulb thermometer on the lab counter and hold a 300 watt incandescent lamp .5m directly above the black bulb for 5 minutes. Record the temperature.

   B) Allow the thermometer to return to room temperature and then repeat the same procedure using a 300 watt infrared bulb. Record the temperature at the end of 5 minutes.
5. Use reference books to locate a graph showing the intensity and type of solar radiation that reaches the earth and record the information in your notebook. Place a copy of the graph in your notebook.

GETTING IT TOGETHER:

1. What evidence have you seen that suggests sunlight contains different types of radiant energy? Explain.
2. Describe ways in which your two diagrams are alike. Should they be about the same? Explain?

ACTIVITY 1

GETTING IT TOGETHER:

3. Compare the color pattern of sunlight and the fluorescent light. How are they different? Do all light sources give off the same type or radiant energy? Why?
4. Based on the results of your experiments, write a paragraph describing the characteristics of solar energy.

ACTIVITY 2

HOW MUCH SOLAR HEAT COMES FROM THE SUN TO YOU?

MATERIALS:

- Two foam cups
- Two thermometers
- Food colors; aluminum foil
- Graduated cylinder
- Metric ruler; watch
- Insulation material (packing foam, crumpled newspaper, etc.)
- Cardboard box (should be the same height as cups; trim if necessary)

METHOD:

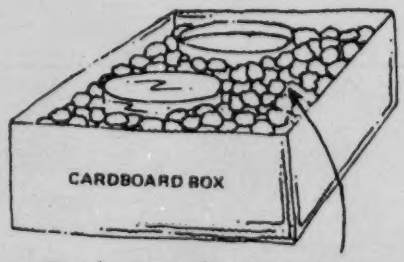
1. Fill the foam cups with 200 ml of cold water. Add food colors to one cup.

2. Cover this cup with aluminum foil to reflect sunlight.

3. Add food colors to H_2O in this cup to make the water as black as possible - this absorbs sunlight.

4. Trim a cardboard box to the same height as the cups. Put the cups in the box and add the insulation material. Put the box in the sun for 10 minutes.
5. Stir the water in the cups with the thermometers and record the temperatures.

Top of box even with top of cups



Pack insulation into all spaces around the cups

ACTIVITY 2

GETTING IT TOGETHER:

1. Fill in the blanks.

CUP 1 (FOIL)		CUP 2 (BLACK)	
T_F _____	C°	T_F _____	C°
- T_S _____	C°	- T_S _____	C°
ΔT _____	C°	ΔT _____	C°

Subtract T_S from T_F to obtain ΔT, temperature gain.

2. Calculate the surface area receiving solar energy by measuring the diameter of the cup and substituting in the equation: $\pi R^2 = \frac{\quad}{CM^2}$

3. Calculate the calories gained each minuted for each cup by:

$$\frac{200 \text{ ml of } H_2O \times \Delta T}{10 \text{ minutes}}$$

Cup 1 _____ calories/minute

Cup 2 _____ calories/minute

4. Estimate the number of calories/square centimeters per minute by:

Cup 1 = $\frac{\text{calories/minute}}{\text{surface/area}}$ = $\frac{\quad}{cal/cm^2/minute}$

Cup 2 = $\frac{\text{calories/minute}}{\text{surface/area}}$ = $\frac{\quad}{cal/cm^2/minute}$

5. Multiply your results in (3) by 10,000 to get an estimate of heat gain per minute for one square meter.

NOTE:

Scientists have measured the amount of solar energy beyond our atmosphere at about 2.0 calories per square centimeter per minute. About 1.5 calories per square centimeter per minute reaches earth after passing through our atmosphere. This is called the Solar Constant.

GOING FURTHER:

1. Explain the difference in ΔT between Cup 1 and Cup 2.
2. Would you have enough energy to heat your house if the south side of your roof was covered with solar collectors?
3. Can you think of a more accurate way to do this experiment?
4. Where do you think most of the errors exist in this experiment?

ACTIVITY 3

METHOD:

1. Fill one dish to a depth of about 2.5cm with dry black soil. Fill the second dish to the same depth with dry white sand. Leave the third dish empty.
2. Place a thermometer in each dish just under the surface of the soil. Make sure that the bulb is completely covered with the soil.
3. Record the initial temperature of the soil, sand, and air.
4. Place the three dishes on a table in direct sunlight. (If artificial light is used, place the dishes so that the light from the incandescent lamp shines equally on each dish.)
5. Take the temperature of the soil, sand, and air every 30 seconds for at least 25 minutes and record on the data table.
6. When the data taking is done lift the dish of dark soil from the table and place your hand under it. Observe whether any solar energy is transmitted through the dark soil. Do the same with both the dish containing the sand and the dish containing the air. Again observe whether any solar energy is transmitted.

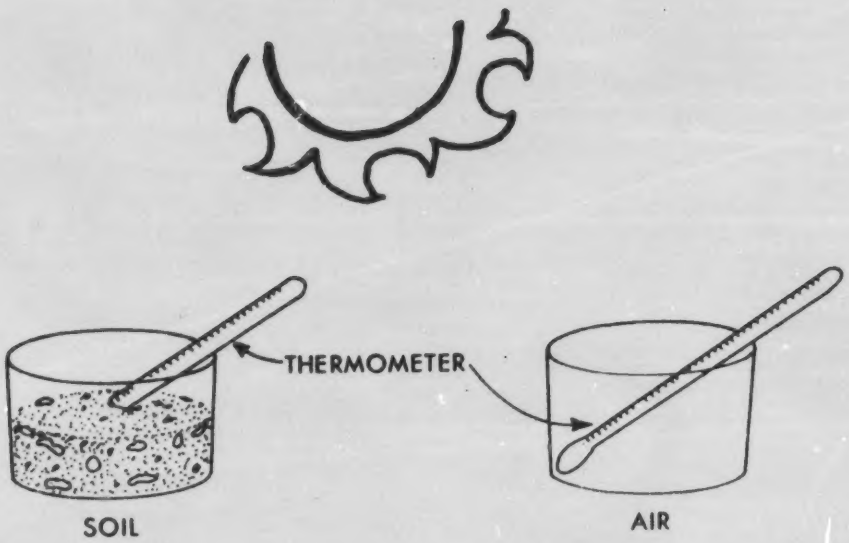
GETTING IT TOGETHER:

1. Construct a graph using the data collected. Use different colors for plotting the changes in the temperature of the sand, soil, and air.
2. Was the temperature of the soil-filled or sand-filled containers higher than the air-filled container? Explain.
3. Why were you told to use one container with only air in it?

The phenomenon of absorption occurs every time light falls on a surface. The light energy is taken into the substance and is changed into heat energy, as is seen in the temperature rise of the soil and sand. This increased heat energy can be explained as an increase in the kinetic energy of the molecules in the substance; light energy in the form of infrared radiation strikes these molecules and causes their motion energy to increase. The color of a substance is also closely related to absorption. Certain wavelengths of light are absorbed, others are reflected. Those which are reflected produce the color of the substance.

ACTIVITY 3

ABSORPTION: WHAT ARE THE BASIC PROPERTIES OF SOLAR ENERGY?



MATERIALS:

- Three glasses or plastic dishes about 10cm in diameter and 5cm high
- Three thermometers, Celsius scale, range -10°C - 110°C
- Dry, black soil to fill one dish
- Dry, white sand to fill another dish
- 200 watt incandescent lamp and reflector with lamp
- Ringstand

  (The last two items for those students who are unable to do this activity in sunlight.)
- A white surface for the experiment to be done on

ACTIVITY 3

DATA TABLE

TIME	DARK SOIL °C	LIGHT SOIL °C	AIR °C
0.00			
0.30			
1.00			
1.30			
2.00			
2.30			
3.00			
3.30			
4.00			
4.30			
5.00			
5.30			
6.00			
6.30			
7.00			
7.30			
8.00			
8.30			
9.00			
9.30			
10.00			
10.30			
11.00			
11.30			
12.00			
12.30			

TIME	DARK SOIL °C	LIGHT SOIL °C	AIR °C
13.00			
13.30			
14.00			
14.30			
15.00			
15.30			
16.00			
16.30			
17.00			
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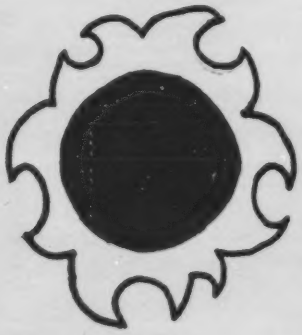
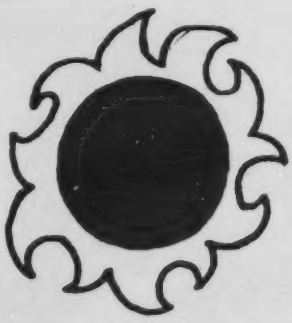
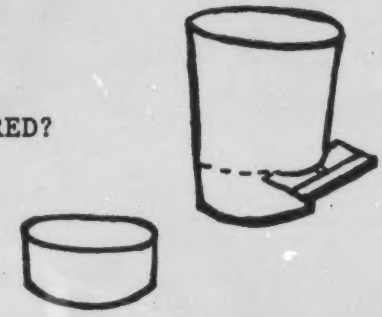




ACTIVITY 4

CAN HEAT ABSORPTION BE MEASURED?

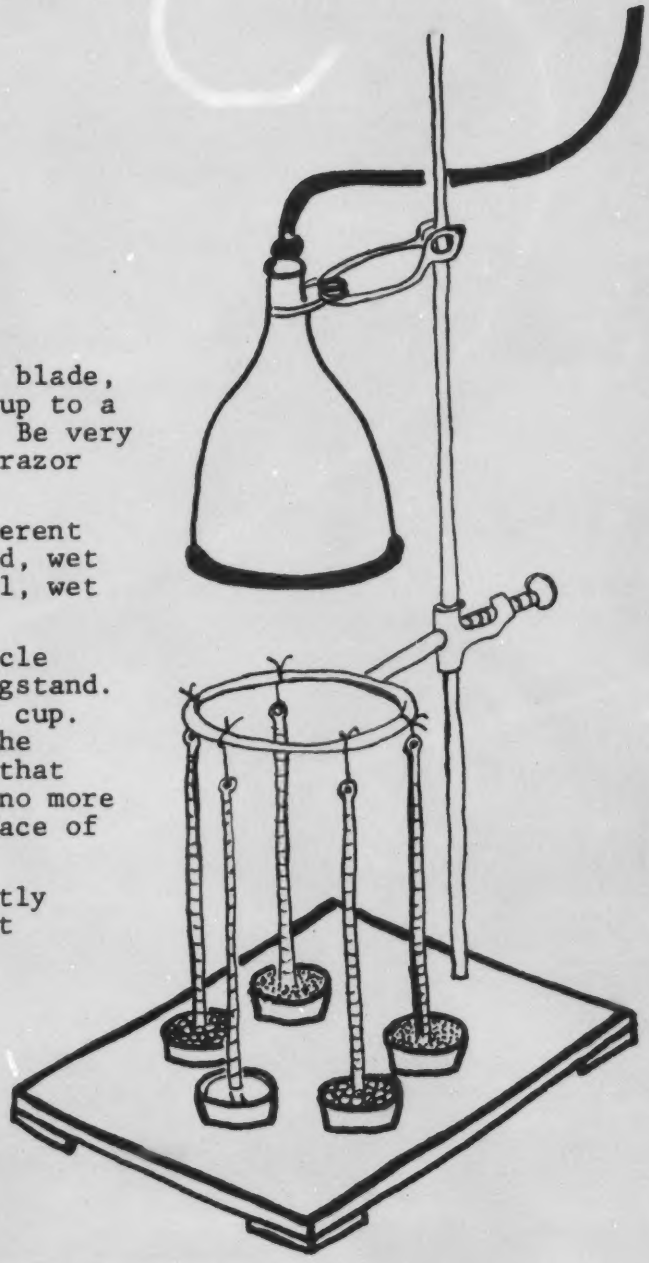


MATERIALS:

- Five styrofoam cups
- Five Celsius thermometers
- Single-edge razor blade
- Clip lamp with a 150-or 200-W bulb
- Meterstick
- Water
- Dry sand
- Finely crushed charcoal
- Ringstand and ring
- String

METHOD:

1. Using a single-edge razor blade, cut down each styrofoam cup to a height of 3cm. CAUTION: Be very careful working with the razor blade.
2. Fill each cup with a different material: water, dry sand, wet sand, dry crushed charcoal, wet crushed charcoal.
3. Arrange the cups in a circle under the ring of the ringstand. Put a thermometer in each cup. Tie the thermometers to the ring, suspending them so that each thermometer bulb is no more than 0.5cm under the surface of the material in the cup.
4. Place the clip lamp directly above the cups at a height of 30cm.



ACTIVITY 4

METHOD:

5. Design your own table for recording data. Enter the temperature shown on the thermometer for each material.
6. Turn on the clip lamp. Record the temperature of the material in each cup after 1, 2, and 5 minutes.
7. Turn off the clip lamp. Again record the temperature of the material in each cup after 1, 2, and 5 minutes.

GOING FURTHER:

1. Construct a graph of the heating data. Represent each material by a different type of line.
2. Which dry material showed the greatest increase in temperature?
3. Which wet solid showed the greatest increase in temperature?
4. Did the wet charcoal or the dry charcoal show greater increase in temperature?
5. Did the wet sand or the dry sand show a greater increase in temperature?
6. How did the increase in the temperature of the water compare to the increases in the temperature of the solids?
7. When the light was turned off, which material showed the greatest decrease in temperature? Which showed the least decrease after 1 minute; after 5 minutes?
8. Write a paragraph describing which material would be best for storing solar heat. Be sure to include the results of your experiment to support your conclusions.

ACTIVITY 5

WHICH MATERIAL STORES SOLAR ENERGY BEST?

MATERIALS:

- Cardboard box
- Black paint
- Four small metal cans
- Four thermometers
- Sand
- Salt
- Water
- Torn-up paper

METHOD:

1. Fill each can with a different material of the same weight.
2. Paint the box black.
3. Place the box in the sun.
4. Place a thermometer in each can.
5. Put the cans in the box, close it, and leave it for 1/2 hour.
6. Now remove the cans.

GETTING IT TOGETHER:

1. Watch the temperatures fall, and record them below. Stir occasionally. Which temperature falls the slowest?

	2 Min.	4 Min.	6 Min.	8 Min.	10 Min.
Salt					
Sand					
Water					
Paper					

2. Which material stores solar heat best?

ACTIVITY 5

BACKGROUND:

One of the biggest problems of making widespread use of solar energy is finding ways to store it when the direct sunlight is not present. Different substances hold heat more efficiently than others. Besides water, substances such as pebbles, air, and Glauber's salt (phase-change) are used to store heat collected from the sun. Storing solar heat is one of the more expensive aspects of a solar heating system for a home. This is the reason why a combination solar and conventional heating system is often more economical and practical. Solar heating systems for swimming pools are extremely practical since the swimming pool acts as its own storage system. The material with the highest specific heat will retain the most heat. Water which has a high specific heat compared to most materials, is the standard. The specific heat of water is 1, while the specific heat of sand is 0.2. This means that water will retain 5 times (1/0.2) as much heat as an equal weight of sand.

STRATEGIES:

BEFORE: Ask the students to predict which material will hold heat longest.

AFTER: Discuss question 2.

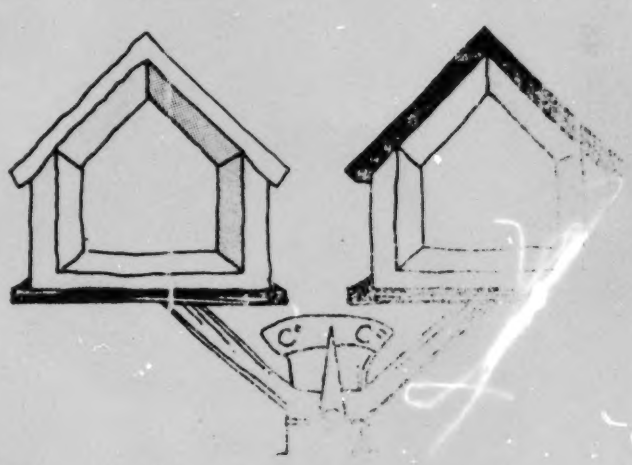
Discuss the application of this concept to building a solar energy heating system.

ACTIVITY 6

WHAT COLOR ABSORBS THE SUN'S HEAT BEST?

MATERIALS:

- White, black, green, red, and blue construction paper, all the same size
- Timer
- Uniformly-sized ice cubes



METHOD:

1. Place an ice cube on top of each sheet of construction paper. Which melts first?

GETTING IT TOGETHER:

1. Would a house with a white roof be cooler than a house with a dark roof?

BACKGROUND:

Dark colors absorb heat much better than light colors, but they also tend to reradiate the heat. This fact has a practical application - choosing a roof or house color. For example, in warm climates, a light colored roof can keep houses cooler.

The reason black absorbs heat best is that it soaks up most of the sun's rays. White reflects most of the light that strikes it.

STRATEGIES:

BEFORE: Ask students to predict which color will melt an ice cube first.

AFTER: Discuss the question.

Students may get varying results. Ask them to try to give reasons for this.

ACTIVITY 7

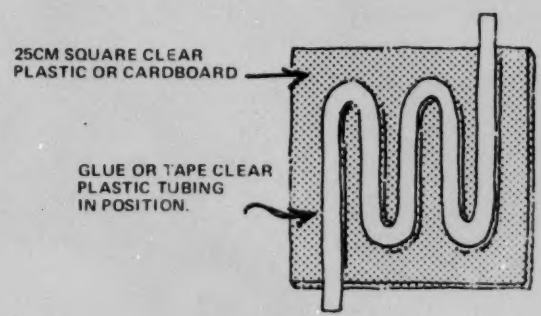
WHICH COLOR LIQUID ABSORBS THE MOST SOLAR ENERGY?

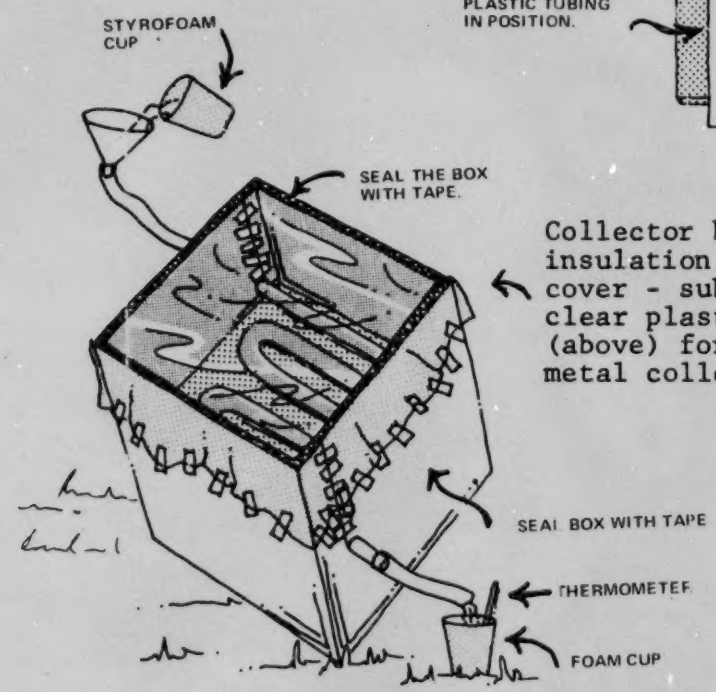
MATERIALS:

- Flat-plate metal collector box, plastic cover, and insulation
- One 25cm square piece clear plastic (1/8" or thicker) or cardboard
- Two meters clear plastic tubing, 3/8" to 1/2" diameter (local hardware store or building supply)
- Glue or tape
- Food colors
- Thermometer
- Two styrofoam cups
- Funnel

METHOD:

1. Construct a Collector Plate





Collector box, insulation, and plastic cover - substitute clear plastic collector (above) for flatplate metal collector

2. Put the clear plastic collector plate in the box and face the collector directly into the sun.

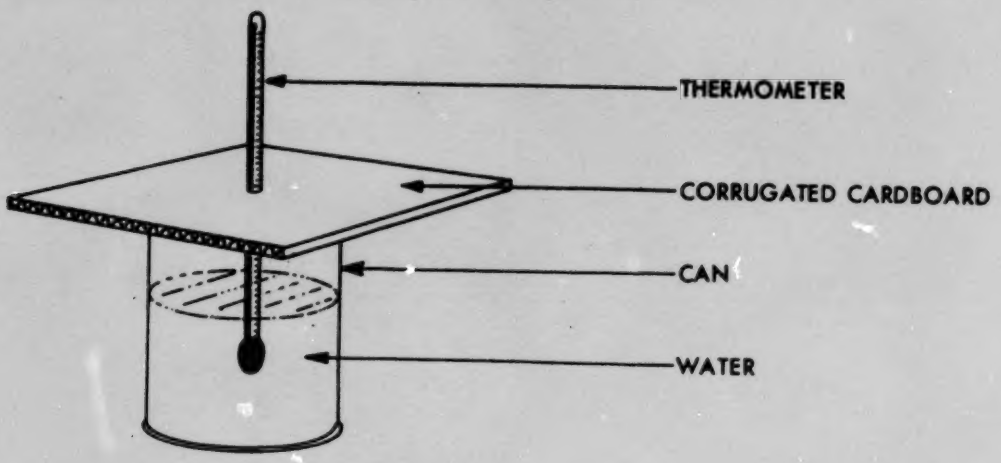
ACTIVITY 7

GETTING IT TOGETHER:

1. Measure and record the temperature of 100 ml H_2O. Pour through the collector 10 times, allowing 5 seconds between pourings. Record the final temperature. Add 2-5 drops red food color to 100 ml H_2O and run through the collector 10 times. What happens?
2. Try other food colors mixed with 100ml H_2O and compare the results with those of the earlier experiments.
3. Make a 100ml mixture of H_2O combining 2-5 drops of each different food color. Pour through the collector 10 times and compare the results.

ACTIVITY 8

RADIATION: HOW DOES IT WORK?



MATERIALS:

- A source of radiant energy, such as a high wattage lamp
- Two thermometers (-10°C to 110°C)
- Two cans of the same size and substance with some type of cover, one painted black and the other left shiny
- Corrugated cardboard
- A clock with a second hand
- Water at room temperature
- Hot water at least 50°C

METHOD:

1. Fill the two cans with equal amounts of water at room temperature.
2. Obtain a piece of corrugated cardboard cut slightly larger than the can top. Make a hole in the center of the cardboard with a pencil point slightly smaller than the diameter of the thermometer. Carefully insert the thermometer in the hole so that there is a snug fit. Repeat for the second thermometer.
3. Place the thermometer and cardboard lid arrangement on each can. Adjust the thermometer so that the bulb of the thermometer does not touch the sides or bottom of the can.

ACTIVITY 8

METHOD:

4. Place each can 20cm from the heat source.
5. Turn on the heat source and record the temperature of the water in the cans every two minutes for about thirty minutes. Record this information in Data Table 1.
6. At the end of thirty minutes remove the heat source, and graph your results.
7. Next, empty both cans and then fill each of them with equal amounts of hot water.
8. Using the same thermometer arrangement as before, record the temperature of the water in each can every 2 minutes for 40 minutes as the water cools. Use Data Table 2.
9. Graph the results for the cooling of the water.

GETTING IT TOGETHER:

1. Which of the cans absorbed the most heat energy? Explain.
2. Which of the cans radiated the most heat energy? Explain.
3. Why do you think that the parts of a solar collector panel that absorbs heat energy are usually painted black.
4. Which colors would be better to wear in the summer, white or black? Explain your answer.

ACTIVITY 8

DATA TABLE 1

TIME (MIN.)	BLACK CAN TEMP. (°C)	SHINY CAN TEMP. (°C)
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		
22		
24		
26		
28		
30		

DATA TABLE 2

TIME (MIN.)	BLACK CAN TEMP. (°C)	SHINY CAN TEMP. (°C)
0		
2		
4		
6		
8		
10		
12		
14		
16		
18		
20		
22		
24		
26		
28		
30		
32		
34		
36		
38		
40		

BACKGROUND INFORMATION:

Radiation is a method of heat transfer in which the heat travels in the form of electromagnetic waves. Heat can travel through a vacuum by radiation only. The light coming from the sun is an example of radiation. All warm objects radiate heat energy, and at the same time receive this energy from other objects in their surroundings. When an object absorbs energy its temperature rises, and when it emits energy its temperature drops.

Various substances radiate energy more rapidly than others. For example, if a silvered container were filled with hot water the heat would not escape very quickly because radiated heat is reflected by smooth surfaces such as shiny metals. In comparison, a black container would emit more heat since black substances do not reflect this energy as well.

ACTIVITY 8

BACKGROUND INFORMATION:

Black is known as the super-absorber. This is because it absorbs light of all wavelengths. When it absorbs the light energy, the molecules composing the black material speed up. The increase in the speed of these molecules leads to a rise in temperature. Therefore, light energy absorbed by this black substance becomes heat energy. On the other hand, shiny or white substances reflect almost all colors of the electromagnetic spectrum, and therefore do not experience such a large temperature change.

This is the reason black is best worn in cold weather, since it takes more light energy and changes it to heat, and white is best worn in hot weather, since it reflects light energy. This phenomenon also explains the use of black in the construction of solar collectors. The top is covered by a transparent plate of glass or plastic, which allows the solar radiation to pass through, and the back is blackened in order to absorb as much solar radiation as possible.

UNIT II

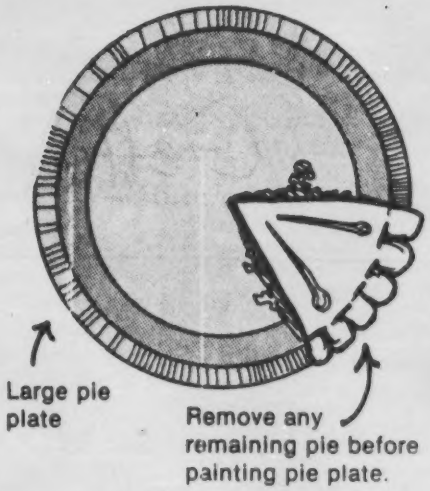
EXPERIMENTS WITH SOLAR COLLECTORS

ACTIVITY 1

IN COLLECTING SOLAR ENERGY, IS BIGGER BETTER?

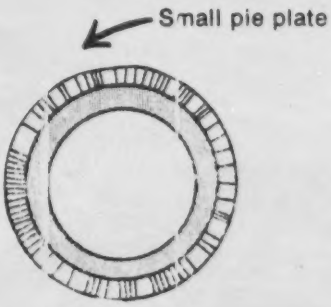
MATERIALS:

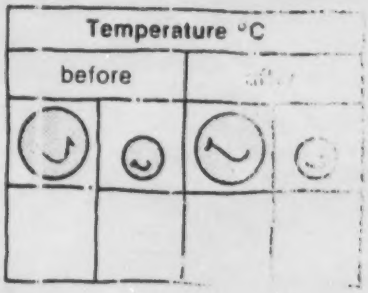
- Large disposable pie plate
- Small disposable pie plate
- Black paint (not water soluble spray paint is easiest)
- Thermometer
- Metric measuring cup
- Clear plastic food wrap
- Newspapers; styrofoam cups
- Masking tape; water
- Candle (teacher's discretion)



METHOD:

1. Paint both pie plates black.
2. When the paint dries, add 100 ml of water to each pie plate.
3. Wrap plastic tightly around them.
4. Tape the plastic securely.
5. Record the temperature of the water in each plate.
6. Place each on a stack of newspapers in the sun for 10 minutes.
7. Now pour the water into styrofoam cups and measure the temperatures. (Record the temperatures on the chart!)





GETTING IT TOGETHER:

1. Which plate had the hotter water?
2. How can this information help you design a solar collector?
3. Write a paragraph describing the relationships between surface area and water temperature shown in your experiment?
4. Is solar energy free?

ACTIVITY 1

BACKGROUND:

More solar energy can be collected by increasing the size of the collector. The percentage that can be collected depends on the amount of sunlight that is available in a particular area. In central and southern Florida a collector with 60 to 80 -ft^2 can provide hot water for the average family. In north Florida more collector area is recommended.

One major problem with solar energy is that it is spread out and very dilute. In order to collect a usable amount of energy, a large area must be exposed to the sun.

STRATEGIES:

BEFORE: Ask the students to predict the water temperatures at the end of the experiment.

AFTER: Discuss the questions.

Ask the students: Why paint the plates black?

Ask the students: Why use plastic wrap?

Ask the students: Why use newspapers?

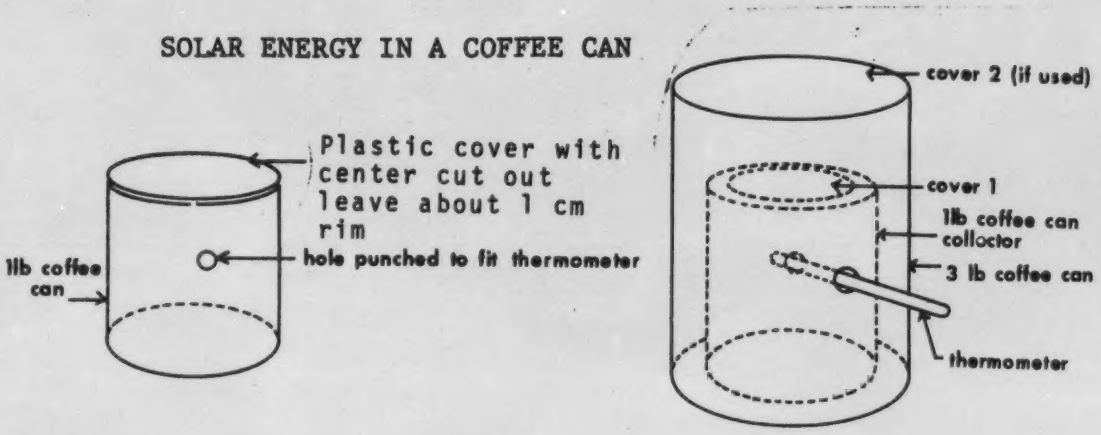
Ask the students: Why pour water into cups before taking the temperature?

Ask the students: Using the materials in this experiment, can they design a better collector?

ACTIVITY 2

HOW DOES A SOLAR AIR HEATER OPERATE?

SOLAR ENERGY IN A COFFEE CAN


Plastic cover with center cut out leave about 1 cm rim
hole punched to fit thermometer
1lb coffee can
cover 2 (if used)
cover 1
1lb coffee can collector
3 lb coffee can
thermometer

MATERIALS:

- A large can about 16cm to 20cm high and 10cm to 13cm wide (a 3 lb. coffee can, for example) with plastic cover
- A smaller can about 10cm high and 7cm wide (a 1 lb. coffee can, for example) with plastic cover
- A standard laboratory thermometer (-10°C to 110°C)
- Several square pieces of transparent and translucent materials such as plastic wrap, polyethylene, waxed paper, etc. (approximately 15cm square)
- Several types of insulation material such as shredded paper (cellulose), cotton, styrofoam, fiberglass, cork, sawdust
- A watch or clock with a second hand
- A can of flat black spray paint

ACTIVITY 2

METHOD:

1. Spray the inside of the smaller can with black paint.
2. Punch a hole in the side of the small can to fit the thermometer.
3. Punch a hole in the outer can so that the thermometer can pass through it. Allow for the insulation being placed in the outer can. Small can will rest on this, not on the bottom of the outer can.
4. Cut the center out of the small can's plastic lid, leaving a 1cm rim. (See diagram on previous page.)
5. Choose one of the cover materials to stretch across the top of the smaller can. Hold the material secure by replacing the cut out plastic lid.
6. Put the small can inside the larger can.
7. Insert the thermometer through the hole in the large can and then fit it snugly into the smaller inside can.

GETTING IT TOGETHER:

1. Place your solar collector in the sun and record the temperature each minute for 15 minutes.
2. Plot the data, temperature vs. time, on a graph. Compare your results to the results of those students who used other cover materials.

A collector or a series of collectors can be used for space heating or to provide hot water for commercial or domestic uses.

The collector constructed in this activity is an integral part of hot air solar systems used for space heating.

ACTIVITY 3

CAN YOU MAKE SOLAR TEA

MATERIALS:

- Tea bags
- Cool water
- Clear glass jar
- Honey

METHODS:

1. Prepare a liter of tea using the solar method. Place a tea bag and a liter of water in a clear glass jar and place it in the sun for a few hours. The color of the tea will tell you when its done.
2. Prepare a liter of tea by the boiling method. Compare the two teas for intensity of color, clarity and taste.
3. Measure the temperature rise as a function of time by taking the temperature of each brew every 15 minutes and putting it on the black board. Continue collecting data throughout the day.

GETTING IT TOGETHER:

1. The next day each student will make his own graph using the collected data.
2. How can you modify your solar teapot to reach even higher temperatures?
3. Will it reach higher temperatures on a reflective surface than on an absorbing surface?
4. Calculate how many calories of heat your tea gained.

   Example: Suppose your tea gained 10°C. Since you used a liter of water and since a calorie is 1 ml of water gaining 1°C then 10°C x 1,000 ml = 10,000 calories.

GOING FURTHER:

Neither the sun nor boiling water is necessary for making tea. The boiling water method is faster but requires the input of non-renewable energy. Solar tea takes 3 to 6 hours, but requires only renewable solar and human energy. Tea steeped in the dark requires human energy and patience.

ACTIVITY 3

GOING FURTHER:

A 10°C rise in temperature is not unusual, and many chemists feel that this minor change in temperature will double the rate of a chemical reaction. Besides, most substances are more soluble at higher temperatures. Boiling water obviously extracts more tannins and alkaloids than does water at room temperature or slightly higher. For example, caffeine is soluble to the extent of 67°g per 100°g of water at 100°C, but only 2.2°g per 100°g at 20°C.

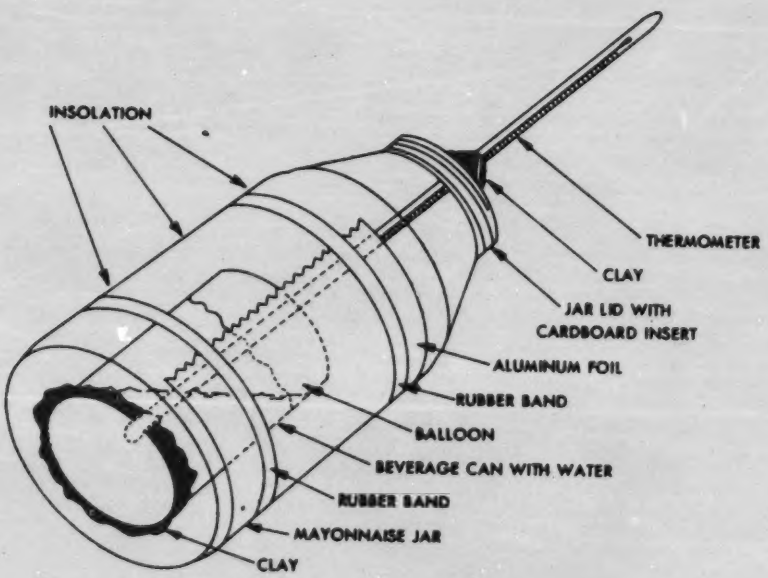
As the tea solution becomes darker, it absorbs more energy, causing the extraction to proceed more rapidly, and the tea becomes still darker. This simulates an autocatalytic reaction.

ACTIVITY 4

CAN THE SUN'S ENERGY BE COLLECTED?

MATERIALS:

- Quart size mayonnaise or canning jar; wide mouth with lid
- 12 ounce aluminum beverage can
- Thermometer, 12", 75 mm immersible 0°C - 100°C
- 50 ml or 100 ml graduated cylinder
- Flat black paint
- Sandpaper
- Paint brush
- Modeling clay
- Balloon or rubber membrane
- Corrugated cardboard
- Aluminum foil
- Rubber bands
- Scissors
- Water
- Clinometer (optional)



ACTIVITY 4

METHOD:

1. Sand the outside of the beverage can so the paint will stick to it. Paint the outside of the can with flat black paint.
2. Cut a circle of cardboard to fit inside the jar lid.
3. Punch or drill a hole in the center of the lid and cardboard so the thermometer will fit through.
4. Put 200 ml of tap water into the beverage can.
5. Cut off the end of a balloon and fit it over the open end of the beverage can. Puncture the balloon to allow the thermometer to pass into the water in the can.
6. Position the beverage can in the center of the jar, anchoring it in position with a small ball of clay by pressing down on the can. Be careful not to spill the water.
7. Screw the lid on the jar.
8. Carefully fit the thermometer into the jar and can positioning it so you can read the water temperature. Do not force the thermometer in or turn the lid once the thermometer is in place. The thermometer breaks easily.
9. Pack a small amount of clay around the thermometer to plug the hole on the lid and make it air tight.
10. Wrap a piece of aluminum foil, shiny side in, around half of the jar. Secure the foil with rubber bands.
11. Enter all initial data on your data sheet. The sun's altitude can be determined with a clinometer or by asking your teacher. REMEMBER NEVER TO LOOK DIRECTLY AT THE SUN BECAUSE IT CAN CAUSE PERMANENT EYE DAMAGE.
12. Place your solar collector on an angle directly facing the sun with the foil side away from the sun. Begin making readings at 3 minute intervals for a total of 30 minutes. Record this information on your data sheet. In the "Notes" column list any changes, such as cloud cover or a movement of the collector, which might occur during the experiment.
13. Graph water temperature vs. time.

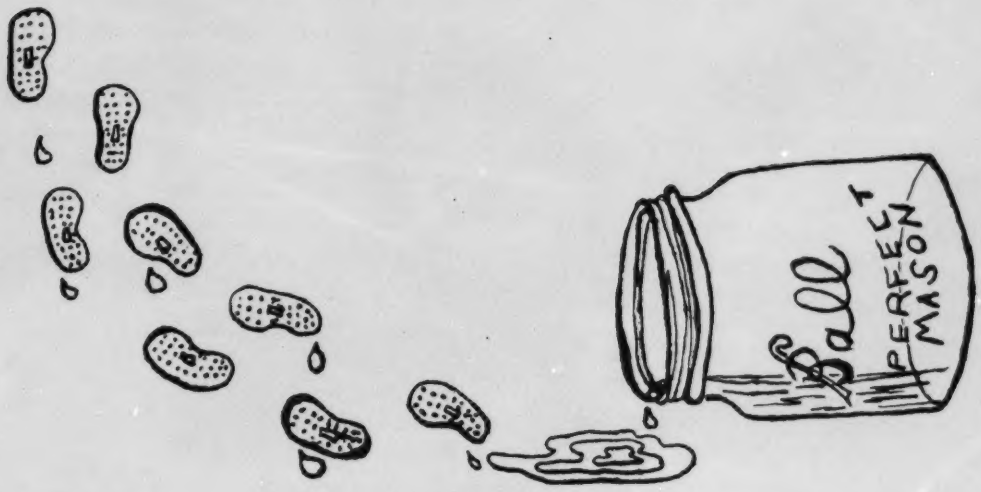
GETTING IT TOGETHER:

1. Interpret your graph. When did the temperature increase the most? Account for any dips or increases in the graph. If your graph leveled off, explain why.

ACTIVITY 4

GETTING IT TOGETHER:

2. List 5 different parts of the collector and explain their functions.
3. How many calories of heat energy were collected in the water? The number of calories = mass of water (in grams) x temperature change (in °C) x specific heat of water which is 1 cal./g°C.



ACTIVITY 4

SOLAR COLLECTOR DATA SHEET

NAME _____

DATE _____

APPROXIMATE ALTITUDE OF SUN _____° (Do not look directly at the sun.)

WEATHER CONDITIONS _____

AMOUNT OF H_2O IN COLLECTOR _____ML

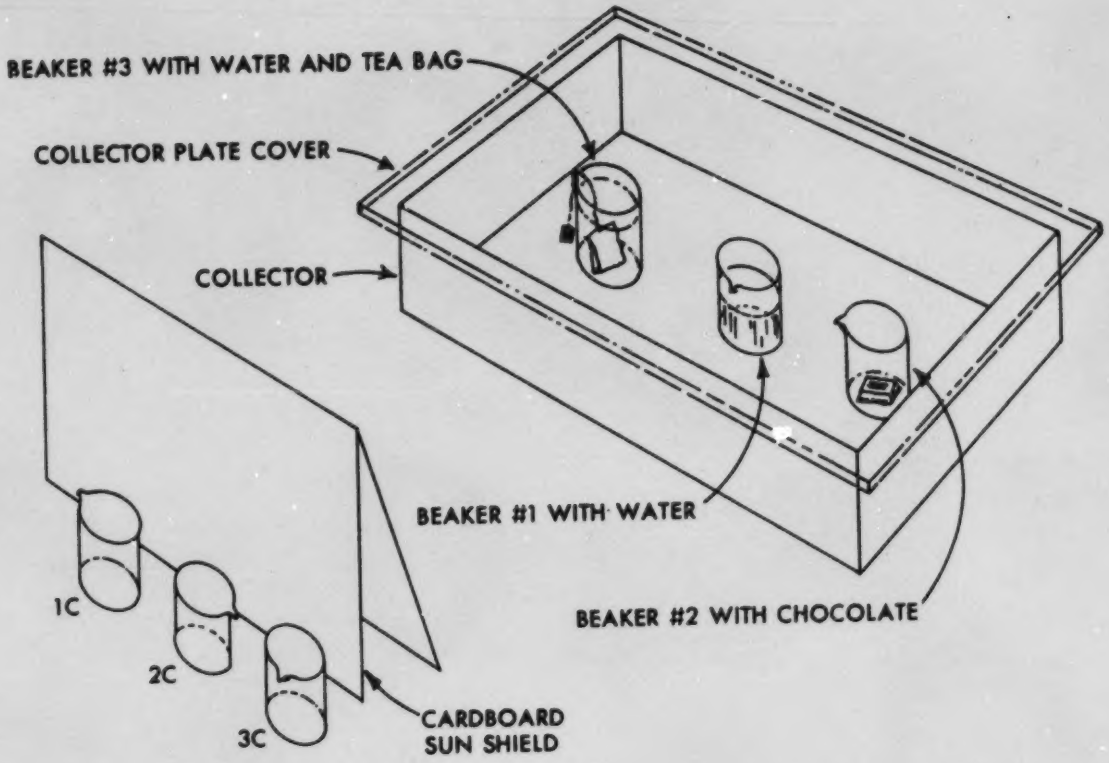
STARTING TEMPERATURE OF H_2O _____°C

OTHER INFORMATION _____

TIME	TOTAL TIME ELAPSED	WATER TEMP.	TOTAL WATER TEMP. CHANGE	NOTES

ACTIVITY 5

HOW DOES SOLAR ENERGY WORK?



MATERIALS:

- For each group collect:
- One solar collector
- Six beakers
- Water
- Two chocolate bars
- Two tea bags
- Six standard laboratory thermometers (-10°C to 100°C)

ACTIVITY 5

METHOD:

1. Set up the solar collector so that it effectively catches the sun's rays.
2. Label 6 beakers as follows: 1, 1C, 2, 2C, 3, 3C. The beakers marked C will be our control.
3. Put a thermometer into each beaker.
4. Place the following substances in the following beakers.

   1 & 1C - Water

   2 & 2C - Chocolate Bar

   3 & 3C - Water and Tea Bag
5. Place beakers 1C, 2C, and 3C in the shade. Place beakers 1, 2, and 3 in the collector.

GETTING IT TOGETHER:

1. Observe the physical appearance of each substance and record your observations.

DATA TABLE 1

BEAKER	INITIAL OBSERVATIONS	FINAL OBSERVATIONS
1		
2		
3		
1C		
2C		
3C		

2. Take the temperature of the substance in each of the six beakers every half hour for two hours. Record this information in Data Table 2.

DATA TABLE 2

TIME (MIN.)	TEMPERATURE IN BEAKERS °C					
	1	2	3	1C	2C	3C
0						
30						
60						
90						
120						

ACTIVITY 5

GETTING IT TOGETHER:

3. After two hours make a second observation of the physical appearance of each substance and record it in the Data Table 1.
4. On a large piece of paper, graph the data from Table 2 using time on the horizontal axis and temperature on the vertical axis.

GOING FURTHER:

1. What conclusions can be drawn from the graphs?
2. Compare the final temperature and appearance of the water in beaker 1 and beaker 1C.
   a. Was there any difference?
   b. How do you account for any difference observed?
   c. Do you see any way that you could use the information that you gained in this experiment in your home?
3. Compare the final temperature and appearance of the chocolate bar in beaker 2 and beaker 2C.
   a. Was there any difference?
   b. How do you account for any difference observed?
   c. Do you see any way that you could use the information that you gained in this experiment in your home?
4. Compare the final temperature and appearance of the water and tea bag in beaker 3 and beaker 3C.
   a. Was there any difference?
   b. How do you account for any difference observed?
   c. Do you see any way that you could use the information gained in this experiment in your home?

ACTIVITY 6

HOW MANY TIMES DO YOU HAVE TO RUN WATER THROUGH A FLAT-PLATE COLLECTOR TO GET A 10° RISE IN TEMPERATURE?

MATERIALS:

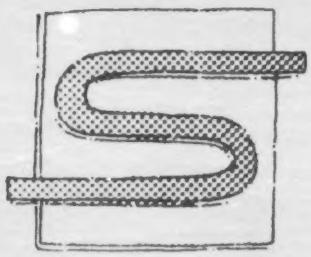
- One 25cm square piece galvanized sheet metal (thinnest sheet available) (local hardware store or building supply)
- One 52cm square piece cardboard
- Flat black spray paint
- Insulation material, 7cm thick x 25cm square (styrofoam, cardboard, newspaper, etc.)
- One meter soft copper tubing, 3/8" to 1/2" diameter (local hardware store or building supply)
- Plastic funnel to fit inside plastic tubing
- 100-200 watt soldering iron and acid-flux solder
- 30cm clear plastic tubing, 3/8" to 1/2" diameter (local hardware store or building supply)
- Razor blade or knife
- Tape or stapler
- Two styrofoam cups
- Two 40cm square pieces 3- or 4-mil clear plastic (local hardware or garden stores)
- Thermometer

NOTES:

Copper tubing must be bent with a tubing bender (about $1.50) or tubing can be bent at the hardware store when purchased.

METHOD:

1. Build a Flat-Plate Metal Collector:

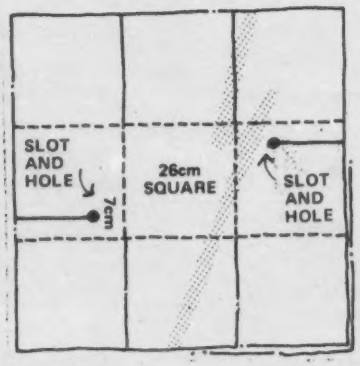


- Bend the tubing carefully with a tubing bender to avoid kinks!
- Solder soft copper tubing to galvanized sheet metal.
- Spray plate and tubing flat black after construction.

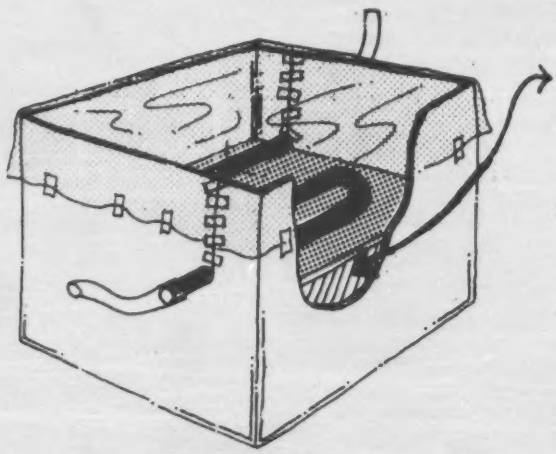
ACTIVITY 6

METHOD:

2. Construct a Box
   - Using a 52cm square piece of cardboard, construct a box to house your flat plate collectors.
   - Cut on solid lines.
   - Fold on dotted lines.
   - Cut slot and hole to insert flat-plate collector.

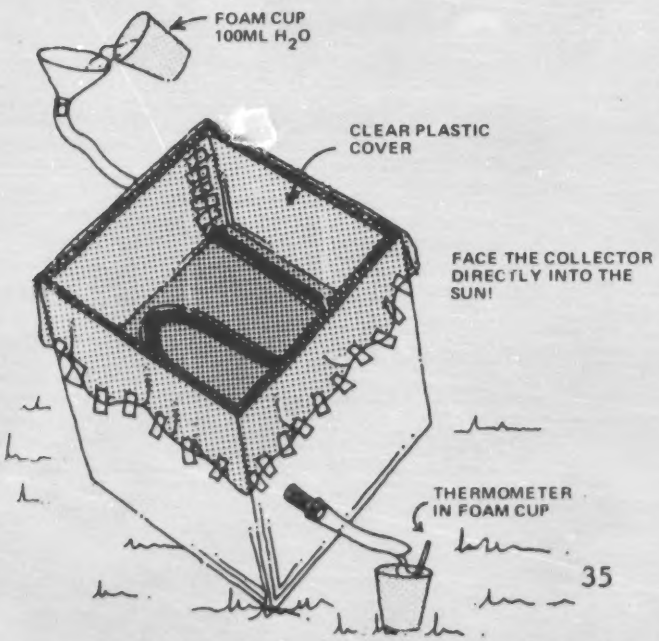


3. Assemble the Collector



- Fold and staple or tape cardboard to make a box.
- Insert the 7cm of insulation.
- Fit the collector into the box. Tape the slots tightly closed.
- Fold and tape the plastic to make a tight but removable cover.
- Fit 15cm clear plastic tubing over ends of copper tubing.
- Check the box to be sure all cracks and holes are tightly sealed!

4. Now the Experiment



ACTIVITY 6

GETTING IT TOGETHER:

1. Measure and record the temperature of 100 ml of H_2O, then pour it through the flat-plate collector until the temperature rises 10° (allow 5 seconds between pourings).
2. How many pouring does it take?
3. Repeat your experiment using different flow rates.

GOING FURTHER:

1. What happens if you try 50ml of H_2O?
2. Try varying the angle at which the collector faces the sun. What effect does this have on your experiment?
3. Make a second box cover of the remaining 3- or 4-mil plastic and place it about 1.25cm above or below the first. Does this have any effect?
4. What is the highest temperature you can reach with your flat-plate collector? How many pourings does it take?
5. Fill the collector tubing with H_2O and allow it to stand instead of flowing out. How hot does the H_2O get after 10 minutes in full sun?

UNIT III

CONCENTRATING SOLAR ENERGY

ACTIVITY 1

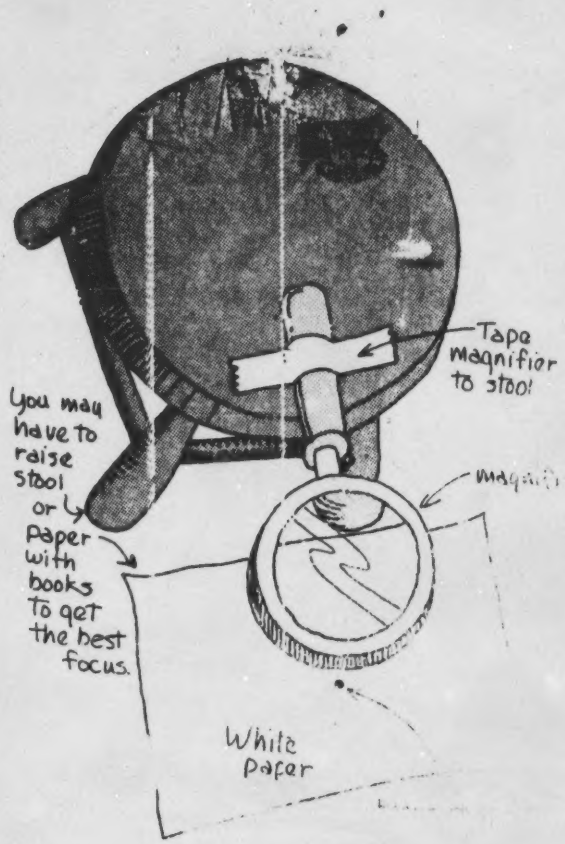
HOW LONG WILL A MAGNIFYING GLASS FOCUS IN THE SAME SPOT AT A CERTAIN TIME?

MATERIALS:

- 6 cm magnifying glass
- Chair or stool
- Masking tape
- Watch with second hand

METHOD:

1. Adjust the lens to the best focus on a piece of white paper or cardboard.
2. Mark its position by making a circle around the light.
3. Measure the time it takes for the light to leave the entire circle.
4. Repeat the experiment at different times during the day.



GETTING IT TOGETHER:

1. How do the results of this experiment show how complicated it is to use reflectors and lenses for the collection of solar energy?

GOING FURTHER:

1. Figure out a way to use the magnifier as a compass.
2. High temperature solar collectors require concentrators and they must be able to "track" the sun. Design a solar collector that can concentrate the available solar energy and track the sun.

ACTIVITY 2

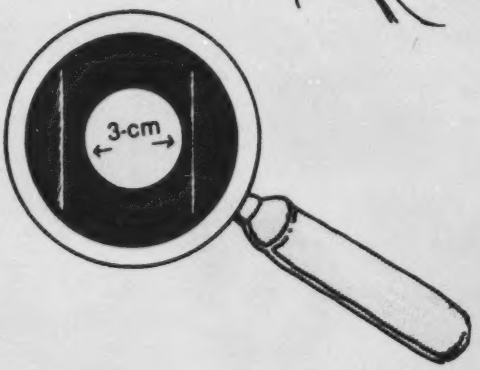
HOW MUCH FASTER CAN YOU BURN PAPER WITH A 6-CM MAGNIFIER THAN WITH A 3-CM MAGNIFIER?

MATERIALS:

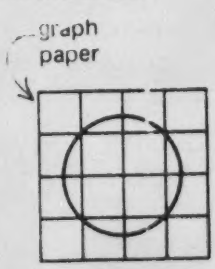
- One 6-cm magnifier (or larger) (1" - 2 1/2 cm)
- Watch
- Scissors
- One sheet heavy black construction paper
- One sheet dark or black light-weight paper
- Compass (or 3-cm round object)

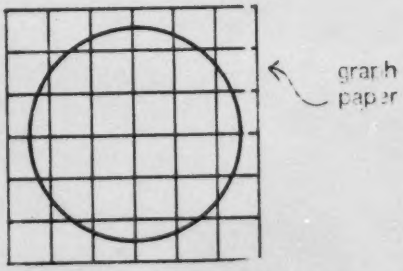
METHOD:

1. Position the magnifying glass so the rays focus the smallest amount of light on a piece of dark or black light-weight paper.
2. How many seconds does it take before the paper starts to smoke? (Be careful - it gets hot!)
3. Now cover the lens with a piece of black construction paper that has a 3-cm hole cut in the center.
4. How long does it take this time?
5. Try it with different colors of construction paper.



GETTING IT TOGETHER:





1. How much more sunlight does the 6-cm lens let in than the 3-cm lens?

ACTIVITY 2

GETTING IT TOGETHER:

2. On graph paper, draw a circle that is 6-cm wide and one that is 3-cm wide. Count the number of squares and parts of squares that each circle covers. What's the total?
3. Does this help explain the results of your experiment? Would the graph exercise be more accurate if your grid was on a 1/2-cm scale?
4. Why use dark or black light-weight paper?

BACKGROUND:

One way to increase the effectiveness of a solar collector is to focus the sun's rays with a magnifier. In order to reach high temperatures throughout the day, focusing collectors must be built to track the sun as it moves across the sky. Since the collectors require direct solar radiation, they do not work on cloudy days. The larger the magnifier, the more the energy can be concentrated. Temperatures as high as 3,500°C have been attained with large lenses.

A 6-cm magnifier is twice the diameter of a 3-cm magnifier. It would appear that it ought to collect twice as much sunlight; in fact, it will collect 4 times as much. A 6-cm lens has 4 times the area of a 3-cm lens, while a 9-cm lens has 9 times the area.

ACTIVITY 3

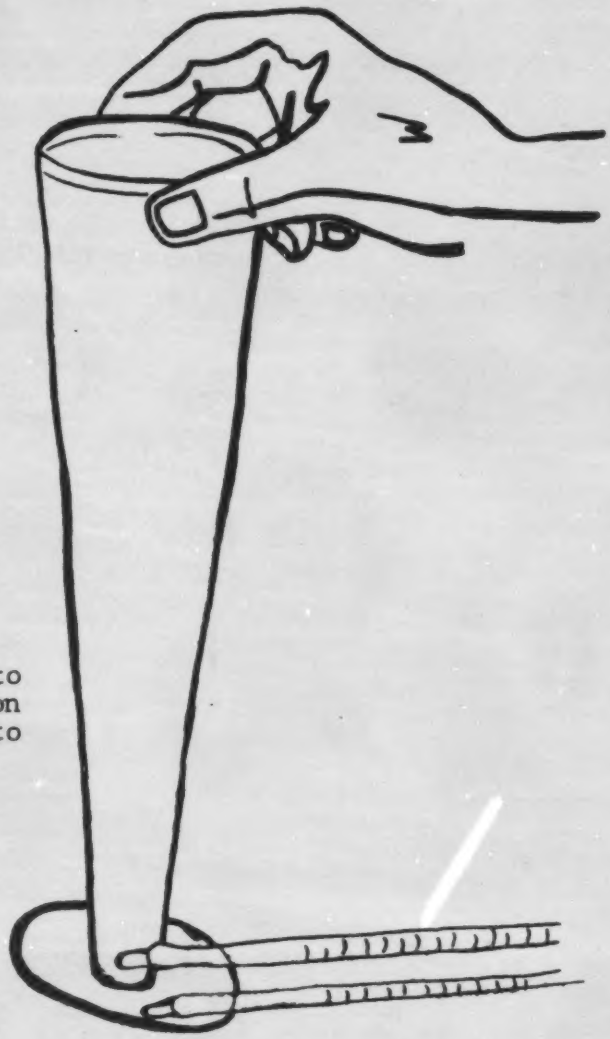
WHAT IS THE EFFECT OF CONCENTRATING SUNLIGHT?

MATERIALS:

- Double-convex lens (5 cm or more in diameter)
- Two Celsius thermometer's

METHOD:

1. Examine Table 1.
2. Work either outdoors or at a window through which the sun shines. Label two thermometers A and B. Read each thermometer and record the temperatures in Table 1.
3. Place both thermometers in sunlight. Read the thermometers every 30 seconds for 5 minutes and record the temperatures. Then take the thermometers out of the sunlight and let them cool to the starting temperature.
4. Examine Table 2.
5. Read each thermometer and record the temperatures in Table 2. Then use the lens to bring sunlight to a sharp focus. Since you will have to hold the lens in this position for some time, you may want to stack some books on which to rest your arm. Place thermometer A so that the bulb is in focused sunlight. Place thermometer B so that the bulb is in the shadow cast by the lens.
6. Read the thermometers every 30 seconds for 5 minutes and record the temperatures. CAUTION: If the temperature recorded by thermometer B reaches 105°C, remove the thermometer from the sunlight.



ACTIVITY 3

METHOD:

TABLE 1 - TEMPERATURE (°C) IN NORMAL SUNLIGHT

THERMOMETER	TIME (m)										
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
A											
B											

TABLE 2 - TEMPERATURE (°C) IN SHADOW AND FOCUSED SUNLIGHT

THERMOMETER	TIME (m)										
	0.0	0.5	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
A (Shadow)											
B (Focused Sunlight)											

GETTING IT TOGETHER:

1. Make a line graph of your data. Plot time on the horizontal axis and temperature on the vertical axis. Use a dotted line for normal sunlight temperatures, a dashed line for focused sunlight temperatures, and a solid line for shadow area temperatures.
2. Does the lens actually concentrate sunlight? Explain your answer.
3. Compare the changes in temperature in normal sunlight, focused sunlight, and shadow. How did the temperature change in the shadow area?
4. Is there evidence that the lens concentrates all the sunlight shining on it? Explain your answer.

UNIT IV

PASSIVE SOLAR EXPERIMENTS

ACTIVITY 1

HOW MUCH WARMER DO THINGS GET IN THE SUN THAN IN THE SHADE?

MATERIALS:

- Two Styrofoam cups
- Two Thermometers
- Watch

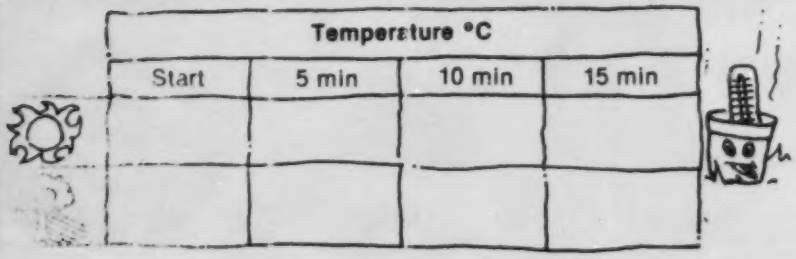
METHOD:

1. Pour equal amounts of cold water into 2 styrofoam cups. (The colder the better!)
2. Place a thermometer in each cup.
3. Set one in the sun and the other in the shade.

GETTING IT TOGETHER:

1. What is the temperature of each after 5, 10, and 15 minutes?

Temperature °C			
Start	5 min	10 min	15 min

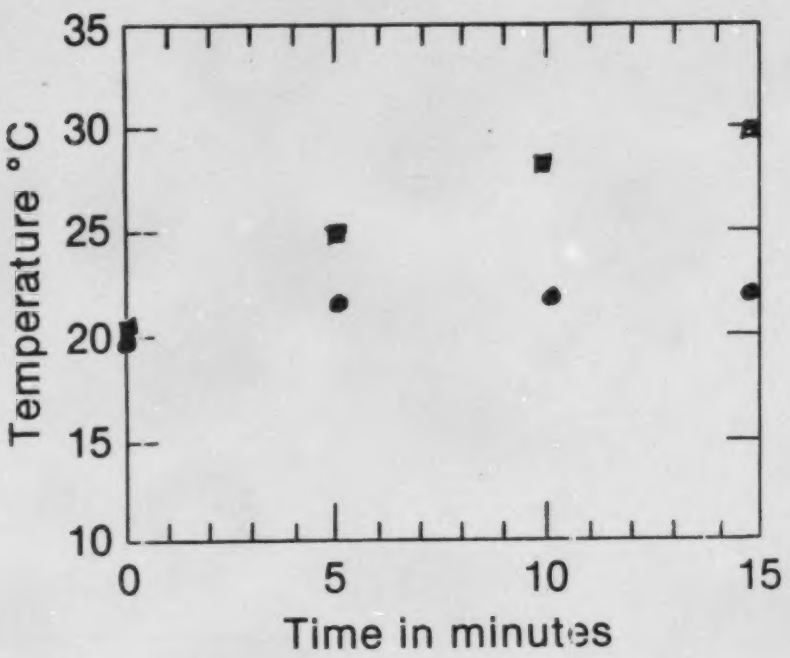


2. What is the temperature difference?

ACTIVITY 1

GETTING IT TOGETHER:

3. Make a graph like the one below, and use it to record the temperatures for 15 minutes. Use different colors for each cup.
4. Would the water in the cup get warm on a cloudy day? On a cold, sunny day?
5. Can a house be heated by solar energy if it is shaded by a big tree?
6. Apply the results of this experiment to your home. Write a paragraph describing your results and how they affect cooling your home.



ACTIVITY 2

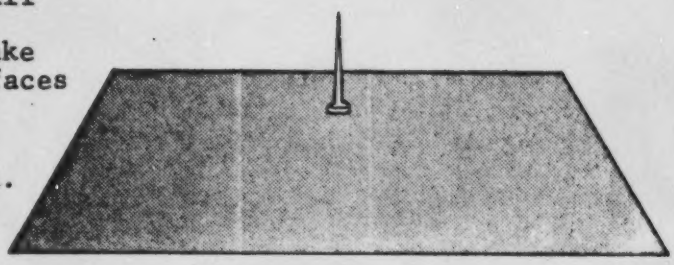
MAKING A SUNDIAL?

MATERIALS:

- Piece of Cardboard
- Large Nail
- Glue
- Clock
- Sunny Day

METHOD:

1. In the morning, put the cardboard in a place where the sun will shine all day.
2. Glue the head of the nail to the edge of the cardboard as shown. Make sure this edge always faces south.
3. Every hour, trace the shadow made by the nail. Write the time next to each tracing.
4. Look at the sundial on another sunny day.

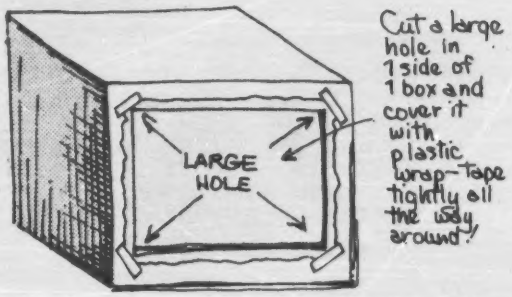


GETTING IT TOGETHER:

1. What time was it when you looked at the sundial?
2. How do you know?
3. Design an experiment using your sundial that would tell you what season it was (winter, summer)!

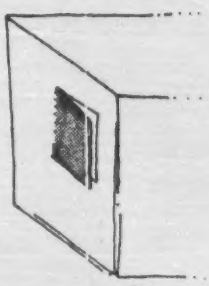
ACTIVITY 3

HOW MUCH HOTTER DOES A HOUSE GET WHEN THE WINDOWS FACE SOUTH INSTEAD OF NORTH?



MATERIALS:

- Two cardboard boxes of same size
- White paint or paper
- Two thermometers
- Plastic wrap
- Masking tape

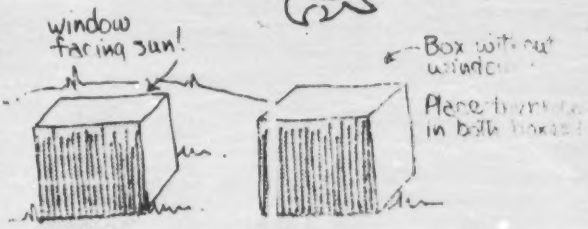


METHOD:

1. Paint both boxes white, or cover them both with white paper.
2. Place a thermometer in each box and put them in the sun.

GETTING IT TOGETHER:

1. Record the temperatures after 10 minutes, 20 minutes, and 30 minutes.
2. What do you find?
3. If you were designing a house in Alaska, on which side would you have the most windows? What about a house in Florida?



TIME: START	10 MIN.	20 MIN.	30 MIN.
Facing Sun			
Facing Away From Sun			

ACTIVITY 3

BACKGROUND:

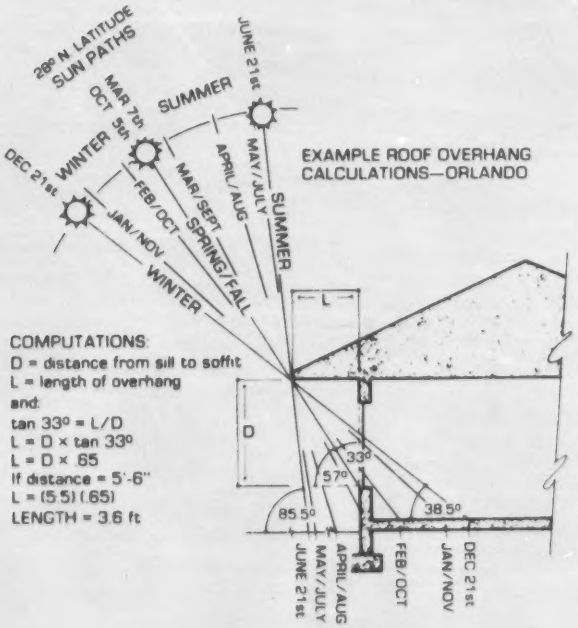
When building or buying a home, taking advantage of solar energy through the proper placement of the house on the lot and the use of windows can help keep down utility bills in Florida. The house should be situated so that the length runs east and west. Most windows should be placed on the south wall and a roof overhand, which controls the sunlight admitted, should extend far enough to keep the sun from shining in the windows during the summertime, but not too far so the sunlight can enter the house in the winter. Double-pane windows will help the house retain the absorbed heat. The number of windows and the size of the overhang has to be adjusted for the climate. Deciduous trees can be used to shade the house in the summer and to allow the sun to heat the house when they lose their leaves in winter.

STRATEGIES:

BEFORE: Ask the students to predict which box will get hotter.

AFTER: Discuss the summary questions.

Ask the students to predict what would happen if the activity were tried at other times of the day or on a cloudy day.

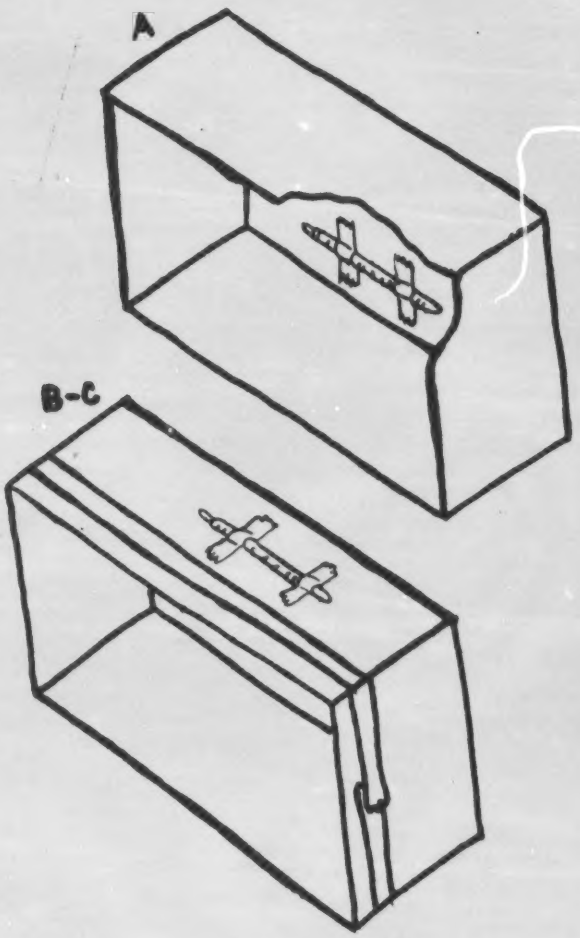


ACTIVITY 4

BUILD A MINIATURE GREENHOUSE

MATERIALS:

- Shoe box
- Clear plastic wrap
- Two Celsius thermometers
- Meterstick
- Cellophane tape
- Clip lamp with 150-200 W bulb (or sunlight)
- Scissors
- Graph paper



METHODS:

1. Tape a thermometer to the inside bottom of the box. Be sure the thermometer is centered.
2. Turn the box so that the open top becomes the side. Tape another thermometer to the outside of the box.
3. Cut a piece of plastic wrap slightly larger than the opening to the box. Tape it in place over the opening.
4. If you can't set up your experiment outside, arrange the clip lamp so that the bulb is 50 cm from the plastic wrap.
5. Design your own table for recording data. Enter the temperature recorded on each thermometer. Then turn on the clip lamp. Record the temperature inside and outside of the box every 30 seconds for 5 minutes.
6. Turn off the lamp. Record the temperature inside and outside of the box every 30 seconds for 5 minutes.

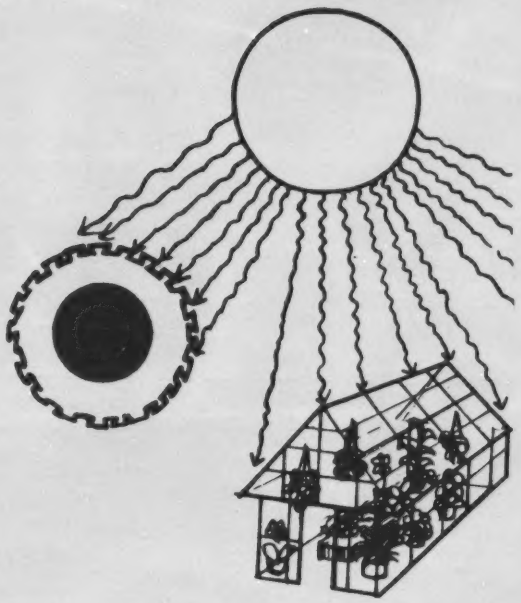
ACTIVITY 4

GETTING IT TOGETHER:

1. What is the dependent variable in your data. What is the independent variable?
2. Construct a line graph of the heating data collected in Step 5 (under Methods). Show temperature on the vertical axis and time on the horizontal axis. Use a solid line for temperature inside, dotted line for temperature outside.
3. Construct a line graph of the cooling data collected in Step 6 (under Methods). Follow the procedure in question 2.
4. How did the temperature changes inside the box compare with those outside the box?
5. How could you change your greenhouse so it would retain heat longer? Change your greenhouse and repeat the experiment. Did your ideas work?

ACTIVITY 5

WHAT IS THE GREENHOUSE EFFECT?



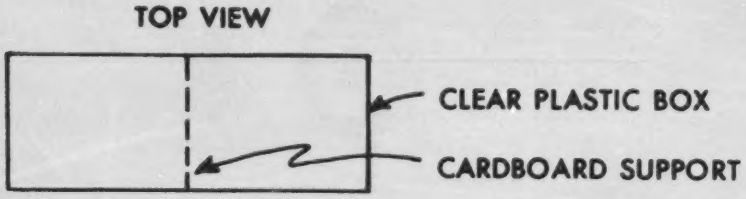
MATERIALS:

- One standard laboratory thermometer (-10°C to 110°C)
- One clear plastic shoe box with cover
- Outdoor reflector flood lamp, and mounting stand if sunlight is not available.
- Soil and water
- Cardboard support for the thermometer

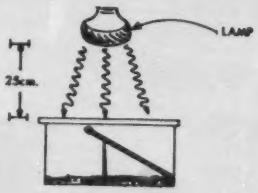
ACTIVITY 5

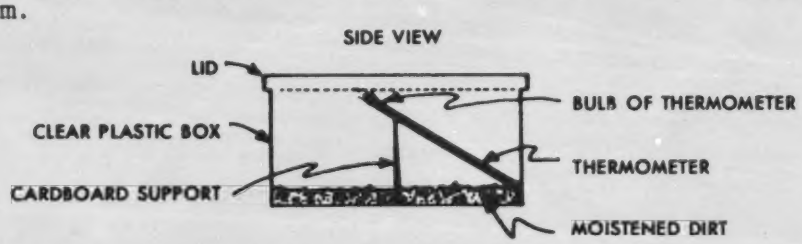
METHOD:

1. Place about 2 cm of soil in the bottom of the clear plastic box. Thoroughly moisten the soil with water.
2. Cut out a piece of cardboard to divide the box in half. The cardboard should not quite reach the top of the box.



3. Lean the thermometer against the cardboard support with the bulb end up.
4. Put the box and lamp in a part of the room where the effects of the direct sunlight, heating, and cooling systems, and drafts will be reduced.
5. Put the lamp directly over the thermometer bulb at a distance of about 25 cm.





6. Record the thermometer reading for 0 minutes on the data table.
7. Turn on the light.
8. Record in your data table the temperature every minute for a total of 15 minutes.
9. Repeat steps 6-8 with the lid on the box.

ACTIVITY 5

GETTING IT TOGETHER:

DATA SHEET

TIME (MINUTES)	COVERED TEMPERATURE ^{o}C	UNCOVERED TEMPERATURE ^{o}C

ACTIVITY 5

GETTING IT TOGETHER:

1. Prepare a line graph of data you collected. Put temperature on the vertical axis and time on the horizontal axis. Use a dashed line for the uncovered box and a solid line for the covered box.

2. Which box gained temperature more rapidly? Which gained more heat?

3. What was the difference in temperature between the uncovered and covered box at 5 minutes, 10 minutes, 15 minutes?

4. Write a paragraph describing the "greenhouse effect" you observed. Be certain to include data from your experiment in the paragraph.

UNIT V

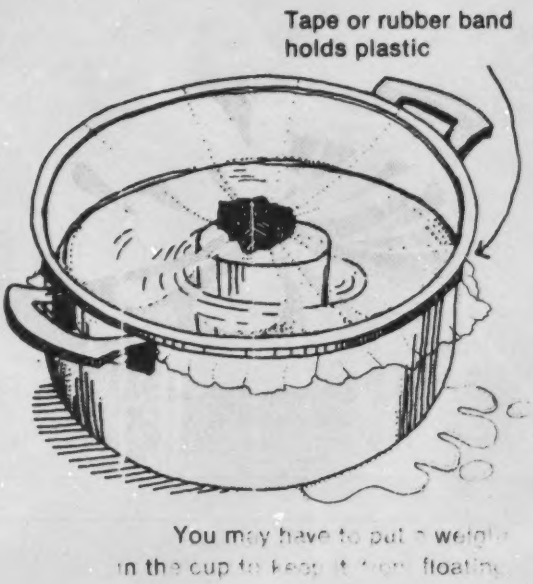
WORKING WITH SOLAR STILLS

ACTIVITY 1

HOW MUCH CLEAN WATER CAN THE SUN GET OUT OF A PAN OF MUDDY WATER IN A SINGLE DAY?

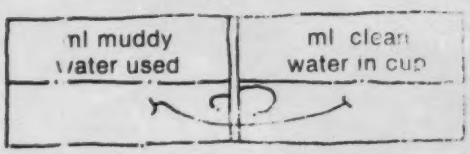
MATERIALS:

- Large pan or tub
- Clear plastic food wrap
- Rock
- Masking tape or rubber bands
- Drinking cup or glass (the heavier the better)



METHOD:

1. Fill a pan to a depth of 5cm with muddy water. How many milliliters of muddy water did you use?
2. Place the drinking cup in the middle and cover the pan with clear plastic.
3. Tape the plastic firmly.
4. Put a rock on the plastic wrap to make it sag in the middle, but don't let the rock touch the cup!
5. As the water evaporates, notice the tiny drops that condense on the cool plastic wrap.
6. How much clean water did you collect?



GETTING IT TOGETHER:

1. Is this a good way for your city to get pure water to drink?
2. Does mud evaporate?
3. Using the results of your experiment, calculate how large a still would be needed to collect one liter of clean water.

ACTIVITY 1

BACKGROUND:

The usual procedure for making pure water from salty or muddy water is to boil it and condense the steam. The U.S. Navy makes pure water for its ships this way.

Using the sun to purify water is one of the earliest applications of solar energy. Solar stills can be used to provide drinking water from salty or polluted water. A solar still on the island of Saint Vincent in the West Indies produces about 1,000 gallons of pure water per day. Nearly forty gallons of oil is required to produce the same amount of pure water. Using wind to speed up the condensation and evaporation processes increases the output of a solar still.

The sun heats the water which evaporates. The water vapor then condenses on the underside of the plastic. As the water accumulates into drops, they become heavy enough to fall into the cup. Impurities are solids which do not evaporate at low temperatures and remain in the pot. At this time, the cost of producing pure water using a solar still is generally too expensive.

STRATEGIES:

BEFORE: Ask students if they know what happens to water when it gets hot and to steam when it cools.

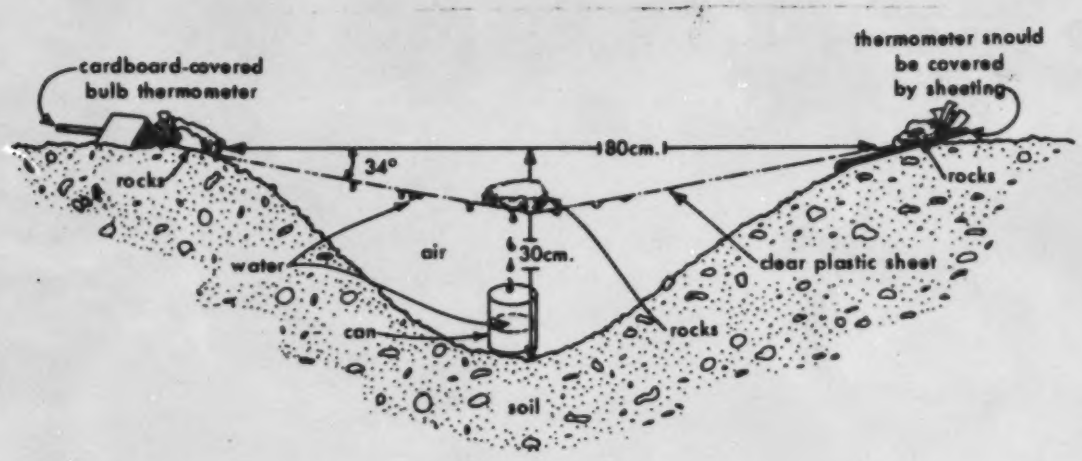
Ask them to predict what will happen to muddy water left in the sun.

AFTER: Discuss the summary questions.

Ask the students if rainwater is pure? Why?

ACTIVITY 2

BUILD A SOLAR STILL



MATERIALS:

- Strong, flexible, transparent plastic sheet at least 1m square; e.g., plastic storm window covering
- Several fist size rocks
- Calibrated collecting can, or other such vessel
- Shovel
- Two thermometers (-10°C to 110°C scale)
- Timing device (wristwatch or stopwatch)
- Piece of cardboard to cover 1/2 of the thermometer
- Graph paper
- Protractor
- Graduated cylinder

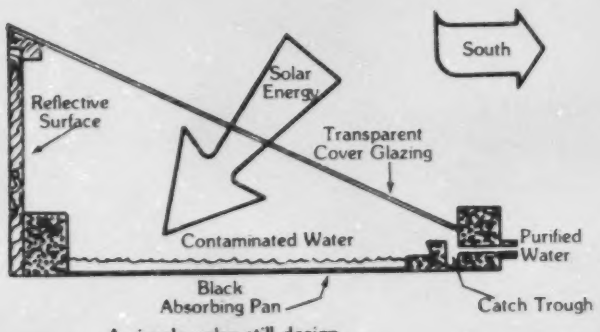
ACTIVITY 2

METHOD:

1. Dig a hole about 80cm in diameter and 30cm deep and place the soil to one side. Center the collecting vessel in the bottom of the hole.
2. Place the piece of plastic over the hole and firmly anchor one edge with small rocks.
3. Place one small rock in the center of the plastic sheet directly over the collecting vessel, and allow the plastic to stretch to at least a 34° angle from the horizontal.
4. Seal the edge of the plastic with soil and small rocks.
5. Insert one thermometer under the plastic sheet with the bulb extending into the air chamber, and positioned so that the scale can be read.
6. Place the other thermometer near the solar still with the bulb covered by cardboard (as shown in the diagram), and positioned so that the scale can be read.
7. Simultaneously record the temperature of both the inside and the outside thermometers at two-minute intervals.

GETTING IT TOGETHER:

1. Construct a data table to record your results.
2. Discuss some practical uses for solar stills.



A simple solar still design.

ACTIVITY 3

MAKE A SOLAR DESALINIZER

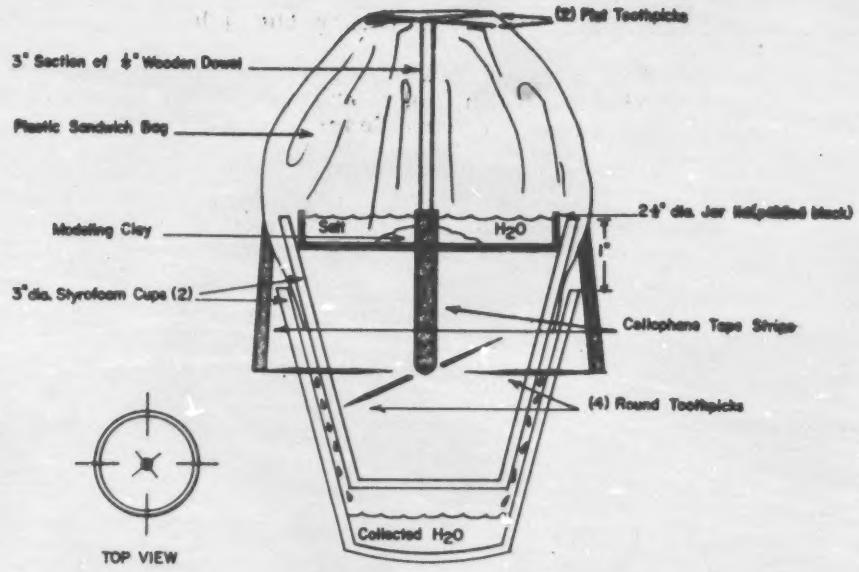
MATERIALS:

- Two styrofoam cups
- Three flat toothpicks
- Four round toothpicks
- One plastic sandwich bag
- One 7.5cm long section of 1/4" wooden dowel
- One piece of modeling clay
- One jar lid
- A small amount of salt
- One ruler (metric)
- One sheet of newspaper
- Black enamel paint
- White glue
- Cellophane tape
- 250ml graduated cylinder

METHOD:

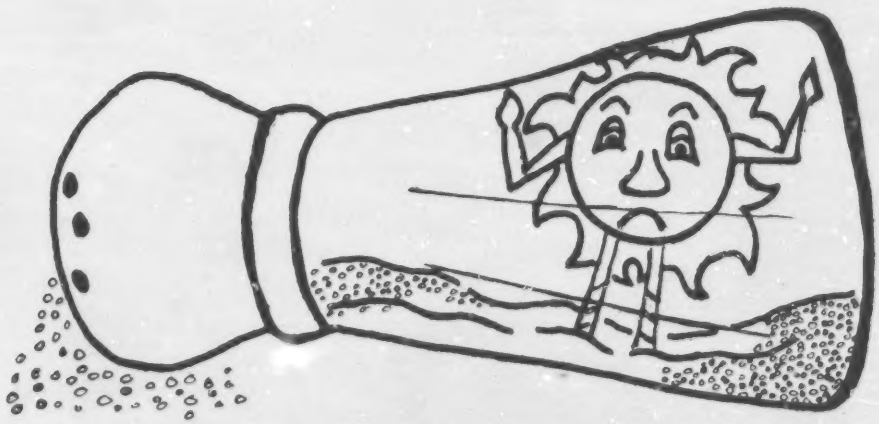
1. Refer to the diagram and the teacher's model as you construct your own solar still. Do not place the plastic bag over the still until your teacher tells you to do so.
2. Pour 125ml of hot tap water into a clean container and add a small amount of table salt.
3. Use clean hands to carefully taste the solution by dipping your finger tip into it and placing it on your tongue. How does it taste?
4. Put enough salt water solution into the jar lid to almost fill it. Be careful not to spill any of the solution into the outer cup.
5. Without letting the plastic bag touch the salt water solution, place it over the two flat toothpicks. Carefully use another flat toothpick to tuck the sides of the bag between the two styrofoam cups.
6. Now put your solar still in the sun for at least 50 minutes.

ACTIVITY 3



GETTING IT TOGETHER:

1. How was salt removed from salt water?
2. How did the taste of the solution in the jar lid compare to the taste of the solution in the outer cup?
3. Energy was required to remove the salt from saltwater. Where did the energy come from?



UNIT VI

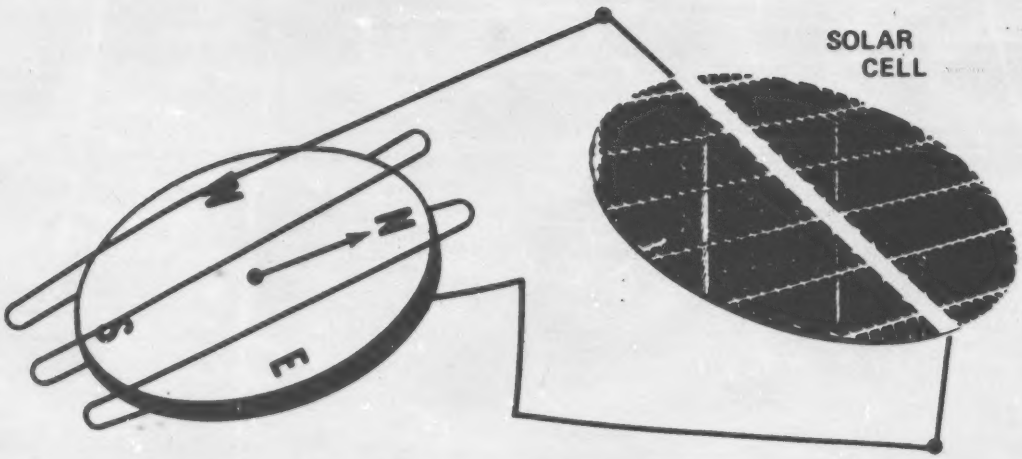
EXPERIMENTS WITH SOLAR CELLS

ACTIVITY 1

MEASURE THE OUTPUT OF A SOLAR CELL WITH A COMPASS?

MATERIALS:

- Photovoltaic cell
- Compass
- Copper Wire



METHOD:

1. Loop thin copper wires (the kind found in discarded telephone cable works well) around the compass 4 to 6 times from north to south.
2. Attach the ends of the looped wire to your solar cell.

GETTING IT TOGETHER:

1. Calibrate the output of your cell over a few hours by graphing the amount of deflection (distance the needle moves from N) over time.
2. Experiment with different orientations: Point the cell east, west, and south. Which produces the most current?

BACKGROUND:

The movement of electricity through looped wire produces an electromagnetic effect, causing the compass needle to deflect proportional to the amount of current being produced by the solar cell. The size of the deflection is also affected by the number of loops in the coil.

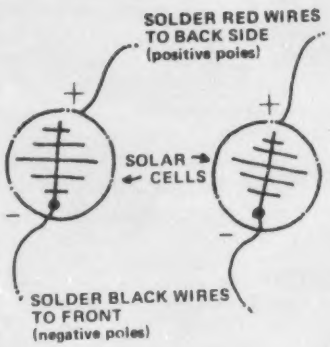
ACTIVITY 2

WHICH DELIVERS MORE POWER TO A MOTOR, TWO SOLAR CELLS IN SERIES OR IN PARALLEL?

MATERIALS:

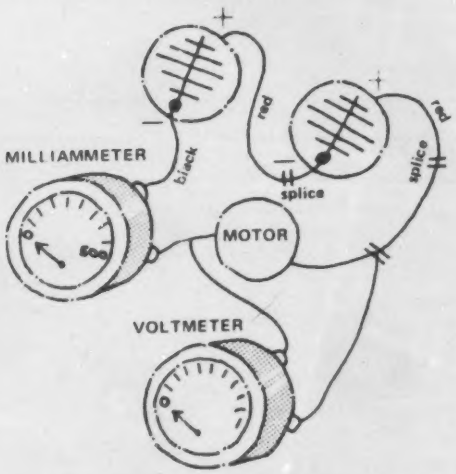
- Two photocells, about .5 volts, 50-100 milliamps (local electronics hobby shop)
- One small motor, 1.5 volt, low-current type (available from the American Museum of Science & Energy)
- One milliammeter, 0-500 ma
- One voltmeter, 0-1 volt
- Rosin-core solder, fine (small diameter)
- Black and red hookup wire (local electronics hobby shop or hardware store)
- Small soldering iron

METHOD:



WIRE THE SOLAR CELL

1. First, wire the solar cells, unless wires are already attached.
2. Following the diagram below, wire the solar cells into a series circuit.



3. Place the solar cells in full sun and measure milliamps and volts.

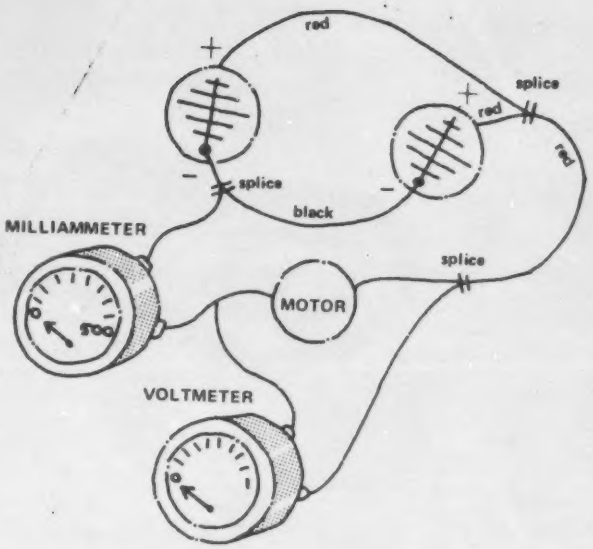
ACTIVITY 2

METHOD:

4. Compute the power generated:

$$\text{Power in watts} = \text{volts} \times \frac{\text{milliamps}}{1000}$$

5. Reconnect the solar cells in a parallel circuit and connect them to the motor, milliammeter, and voltmeter.



NOTE:

If the meter needle goes the wrong way, reverse the leads to the meter.

GETTING IT TOGETHER:

Compute the power using the formula above.

ACTIVITY 3	WHAT IS THE MINIMUM NUMBER OF PHOTOCELLS REQUIRED TO OPERATE A SOUND GENERATOR?

MATERIALS:

- D cell
- Small soldering iron
- Rosin-core solder (small diameter)
- One block of wood, about 10cm square
- Two small wood screws

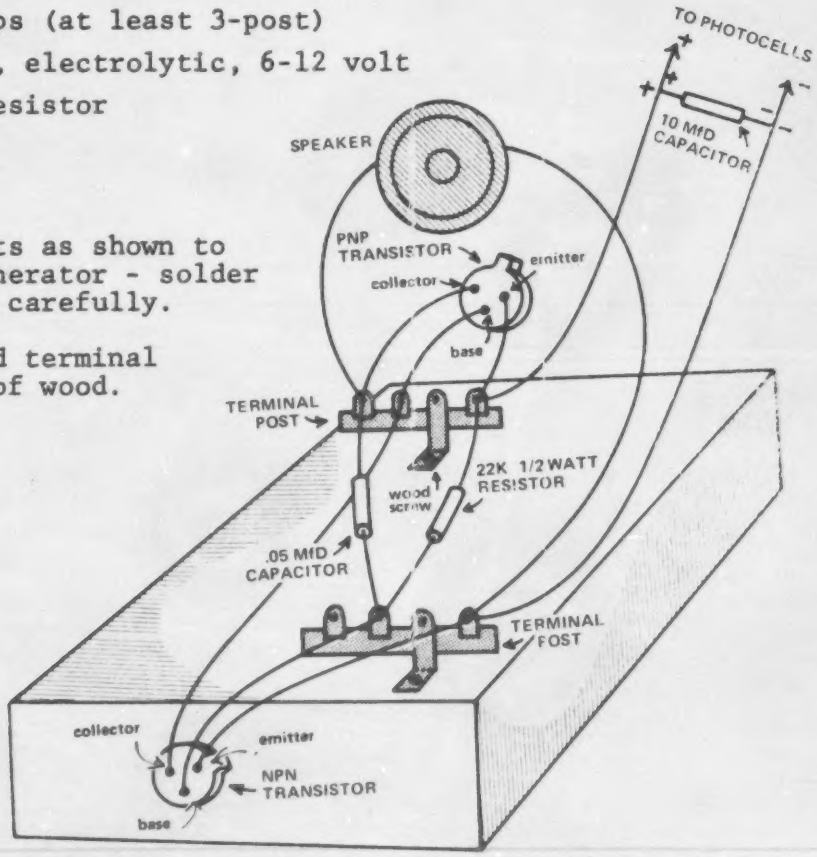
NOTE:

Try a local electronics hobby shop for the supplies below:

- A number of photocells
- NPN and PNP germanium transistors (bargain basement type will do)
- .05 MfD capacitor, electrolytic, 6-12 volt
- Small speaker
- Two terminal strips (at least 3-post)
- Ten MfD capacitor, electrolytic, 6-12 volt
- One 22 1/2 watt resistor
- Hookup wire

METHOD:

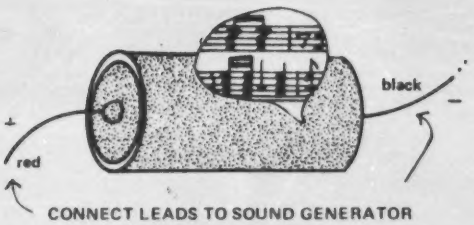
1. Connect the parts as shown to make a sound generator - solder all connections carefully.
2. Wood screws hold terminal posts to block of wood.

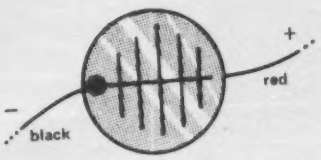


ACTIVITY 3

METHOD:

3. Test your sound generator.
4. To test the sound generator, connect a D cell to the photocell leads and place the sound generator in direct sun - you should hear a tone!
5. Remove the battery and connect a photocell to the sound generator. Does it work?

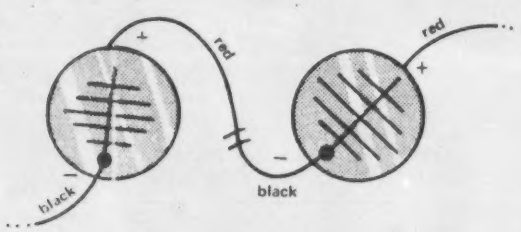




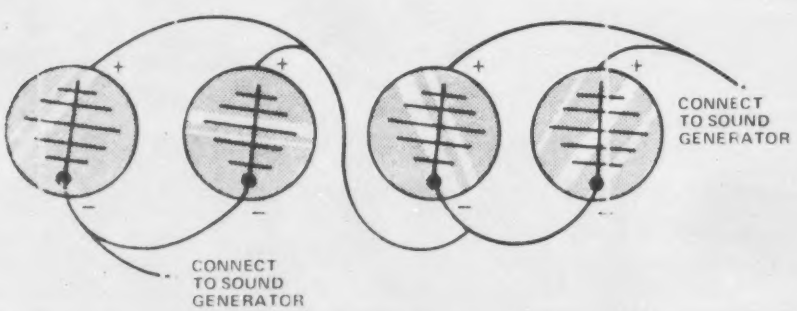
NOTE:

If you don't hear a tone, check connections or check for a faulty transistor.

6. Now try these other combinations.
7. Now try connecting 2, then 3 photocells to the sound generator.
8. Compare the results.



9. Try connecting 4 cells in this parallel series. Which connection gives the best results?



UNIT VII

UNDERSTANDING BIOENERGY

ACTIVITY 1

WHY ARE PLANTS GREEN?

MATERIALS - PART A:

- Alcohol
- Beaker
- Heating unit
- Mortar
- Pestle
- Sand
- Spinach
- Test Tube
- Water

METHOD:

1. Plants are green because they contain chlorophyll. You can easily remove the chlorophyll from leaves. Spinach works well.
2. Use a mortar and pestle to grind some leaves with sand and alcohol.
3. Allow the green-colored alcohol to stand for some time and evaporate down to 1 or 2 ml.
4. You may wish to heat the alcohol and chlorophyll mixture in a test tube in boiling water. The green material left in the test tube is a mixture of chlorophyll and other pigments that can be used in the next activity.

CAUTION:

Do not use a flame to heat the alcohol because it may cause a fire. Use a heating unit instead.

MATERIALS - PART B:

- Green material
- Jar with lid
- Filter or blotting paper
- Glass rod
- Scissors
- Solvent
- Tape

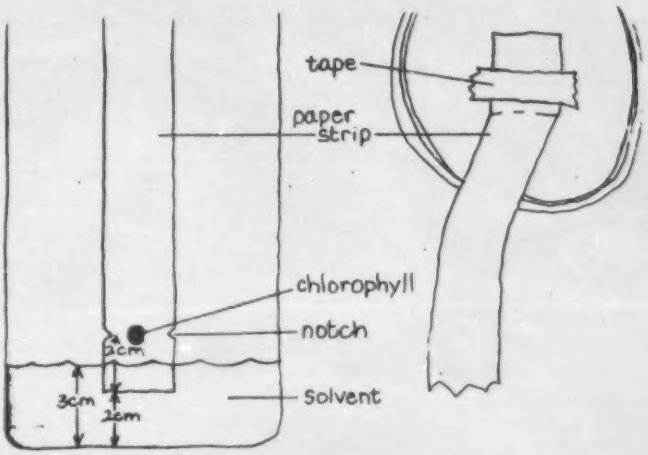
ACTIVITY 1

METHOD:

1. Chlorophyll is not the only pigment in plants. Plants also contain red, orange, and yellow pigments. But since there is usually more chlorophyll than the other pigments, the other colors are hidden. The beautiful autumn leaf colors in some parts of the country are caused by the loss of chlorophyll in the dying leaves. When the chlorophyll disappears from the leaf, the other pigments can be seen.

2. You can separate the other pigments from chlorophyll. If you put a small amount of leaf pigments on a special piece of paper and dip it in solvent, the pigments will "climb up" the paper. Different pigments climb at different speeds. Even though all the pigments start climbing at the same time, some pigments move faster than others.

3. Cut a piece of white blotting or filter paper into a long strip. Use a glass rod to place a spot of evaporated green material from the previous activity on the strip of paper. Allow it to dry, and then put another drop on the paper in the same place. Cut a notch on the side of the paper strip to mark where the dot is. Hang the blotting paper in a jar that has solvent in the bottom as shown in this picture.



CAUTION:

Be sure that the green dot is dry and is not dipped in the solvent.

Wait until the solvent creeps up to near the top of the paper. When it reaches the top, take the paper strip out of the jar, and let it dry. What do you see? Which pigment moved up the paper the fastest?

ACTIVITY 1

GETTING IT TOGETHER:

1. Plants are green because they contain _____ophyll. This pigment is in the _____oplasts.

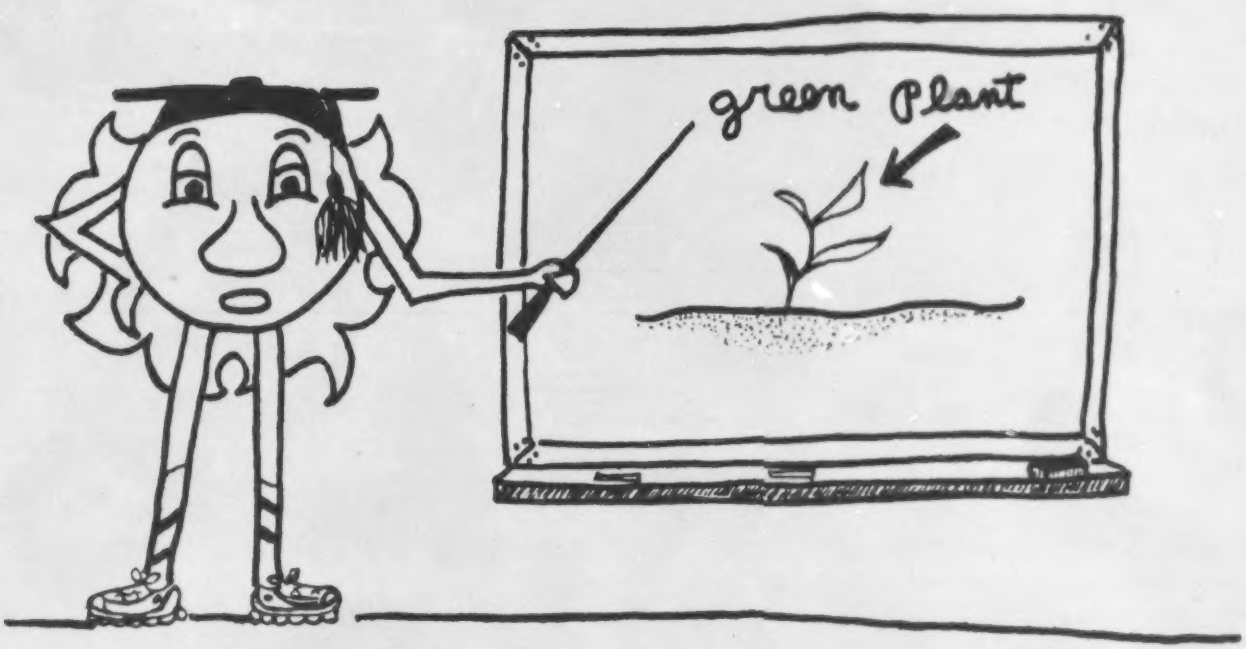
2. In autumn the green leaf color disappears. What colors are seen then?

3. Try to tell what a plant uses each of these for:

   chloroplasts carbon dioxide water
   sunlight oxygen

4. Pick out the three words that you think are most important to photosynthesis. Tell why you picked the words:

   chlorophyll stem water carbon dioxide
   sun energy oxygen root



ACTIVITY 2

CAN YOU SEE SIGNS OF PHOTOSYNTHESIS?

MATERIALS:

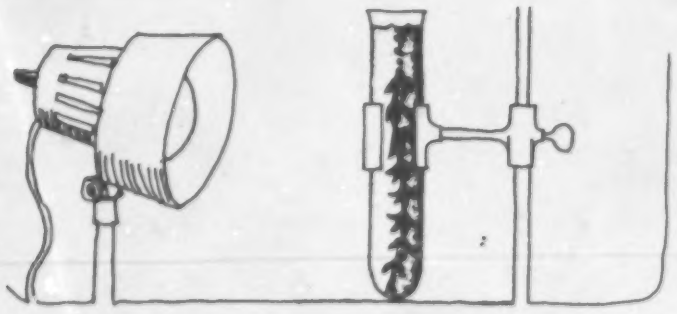
- Clamp
- Elodea Sprig
- Knife
- Lamp
- Ring stand
- Sodium Bicarbonate
- Large test tube
- Water

METHOD:

1. Cut off the end of the stem of a fresh, young piece of Elodea with a sharp knife.
2. Put the stem into a large test tube. Cover the Elodea with water.
3. Place a bright light 30 centimeters from the test tube, and carefully watch for bubbles near the end of the stem.
4. Count the number of bubbles during a two-minute period.
5. Count again every two minutes until you have made three counts. Record your counts in the table.

TABLE 1 -- Lamp 30 Centimeters From Elodea

MINUTES	NUMBER OF BUBBLES
2	
4	
6	



ACTIVITY 2

METHOD:

6. Now move the lamp away from the Elodea until it is twice as far away, or 60 centimeters away. Count the bubbles again and record your counts in Table 2.
7. Add a few grams of sodium bicarbonate to the water in the test tube. Move the lamp so that it is 30 centimeters from the Elodea. Record your counts in Table 3.

TABLE 2 -- Lamp 60 Centimeters From Elodea

MINUTES	NUMBER OF BUBBLES
2	
4	
6	

TABLE 3 -- Lamp 30 Centimeters From Elodea

MINUTES	NUMBER OF BUBBLES
2	
4	
6	

GETTING IT TOGETHER:

1. How does the distance of the light from the Elodea affect the rate of photosynthesis?
2. How does sodium bicarbonate affect photosynthesis?
3. Identify some ways to increase the rate of photosynthesis in a greenhouse.
4. What were the bubbles you counted? How does that relate to photosynthesis?
5. Write the chemical equation for photosynthesis.

GOING FURTHER:

Redesign this experiment introducing additional variables to determine their effect on the rate of photosynthesis.

ACTIVITY 3

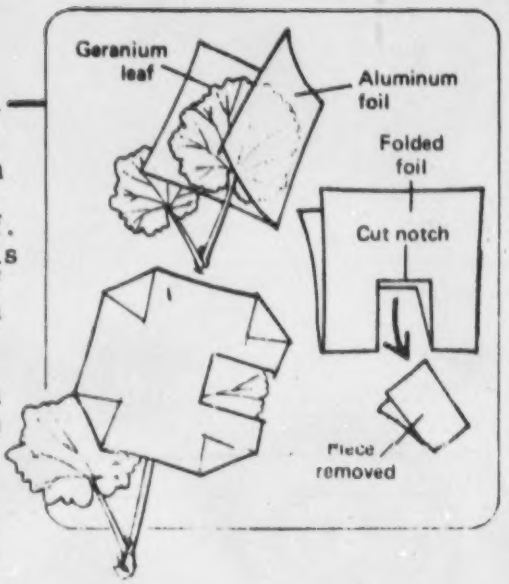
ARE LIGHT AND CHLOROPHYLL NEEDED FOR PHOTOSYNTHESIS?

MATERIALS:

- Geranium plants (plain and varigated)
- Aluminum foil
- Scissors
- Beaker, 100 ml
- Alcohol
- Beaker tongs
- Water bath
- Hot plate
- Lugol's solution
- Graduated cylinder

METHOD:

1. Choose a leaf on the plain geranium plant that you will use for your experiment. Do NOT remove the leaf. Cut a piece of aluminum foil that is large enough to cover both sides of the leaf when the foil is folded in half. Fold the aluminum foil in half. Cut a notch in the folded foil as shown in the picture. Open the foil enough to slip it over the leaf. Then press the edges of the foil around the leaf so that it is held in place. Both sides of the leaf are now covered by the foil except for the notch. Place the plant in sunlight for 3 to 4 days.



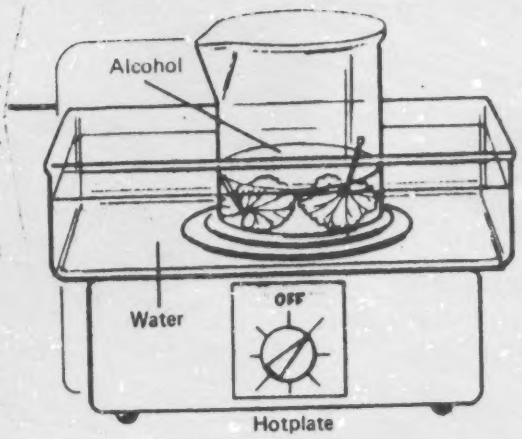
*Which part of the leaf will receive sunlight?

2. Cut the leaf from the plant and remove the foil. Place the leaf in a beaker. Cut another leaf from the plant to use as a control. Place the second leaf in the beaker, also.

*Which parts of the control leaf received sunlight?

ACTIVITY 3

METHOD:



3. The green color of the chlorophyll will interfere with the test for starch. To remove the chlorophyll from the leaves, add 25 ml of alcohol to the beaker. Place the beaker in a water bath. Gently heat the water bath on an electric hotplate for about 5 minutes. (Do not use a flame, because the alcohol might start to burn.)

   *What happens to the color of the leaves?

   *What happens to the color of the alcohol in the beaker?

   *What do you think causes this color change?

4. With a pair of tongs, remove the beaker from the water bath. Pour off the alcohol down the drain. Cover both leaves with Lugol's solution, and let stand for a few minutes. Draw and color the two leaves to show your results.

   *Where was starch found in the experimental leaf?

   *Where was starch found in the control leaf?

5. Remove a leaf from a varigated geranium plant.

   *Which parts of the leaf contain chlorophyll?

6. Remove the chlorophyll from the leaf and test it for starch, as in Steps 2, 3, and 4.

   *Where did you find starch in the varigated leaf?

GETTING IT TOGETHER:

1. What are the raw materials for photosynthesis?

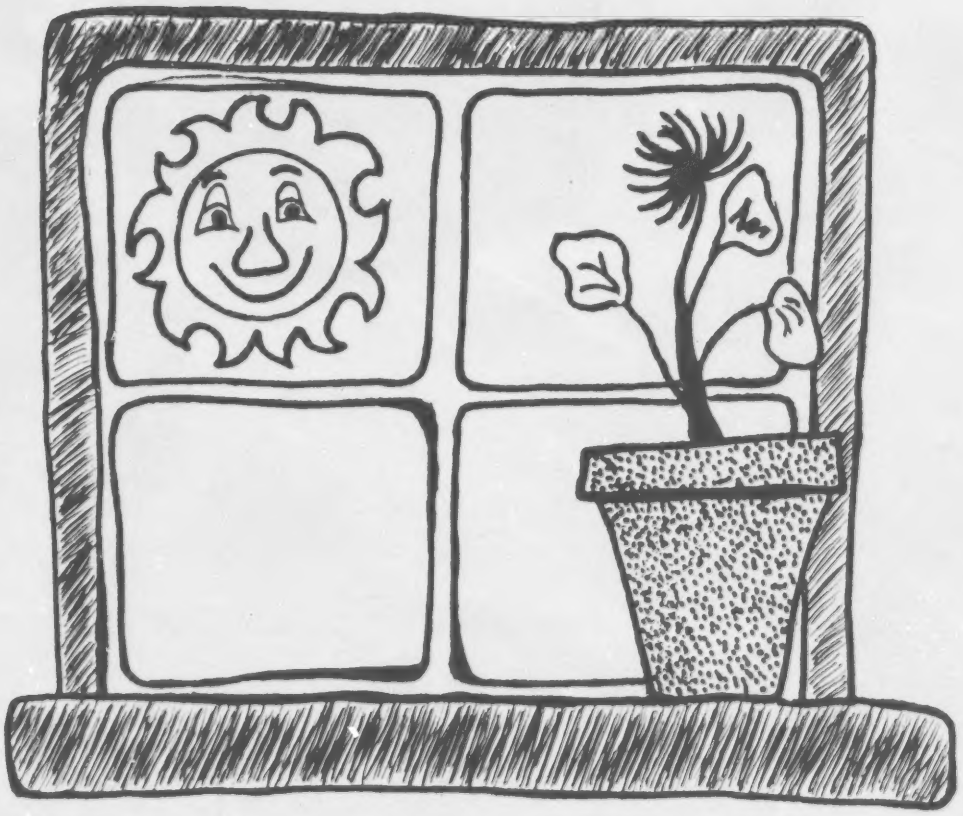
2. What is the source of energy for photosynthesis?

3. What material must be present for photosynthesis to occur?

ACTIVITY 3

BACKGROUND:

Green plants can make carbohydrates from carbon dioxide and water. This process is called photosynthesis. The carbohydrates are stored as starch in plant leaves. We can test a leaf for starch to find out if photosynthesis was going on in the leaf.



ACTIVITY 4

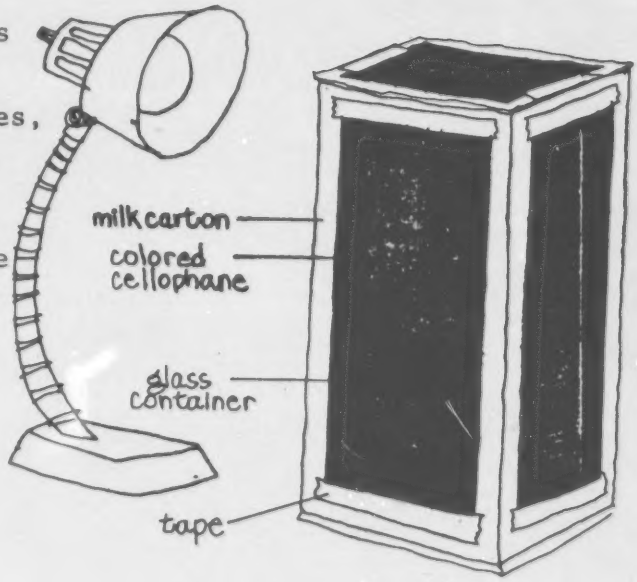
DO DIFFERENT COLORS OF LIGHT CHANGE THE RATE OF PHOTOSYNTHESIS?

MATERIALS - PART A:

- Milk carton
- Sheets of colored cellophane
- Glass container
- Elodea sprig
- Scissors
- Tape
- Test tube
- Water

METHOD:

1. Divide your class into groups; each group will be given a milk carton and a different colored sheet of cellophane.
2. Place the Elodea plant in a test tube of water. Cut "windows" out of a milk carton or box.
3. Cover the "windows" and top of the carton with cellophane.
4. Place the test tube in a glass container in the carton.
5. Count bubbles every two minutes, three times. Record your observations in a table like the one on the next page.
6. Repeat the trial a second time. Record your observations in a new table.



ACTIVITY 4

METHOD:

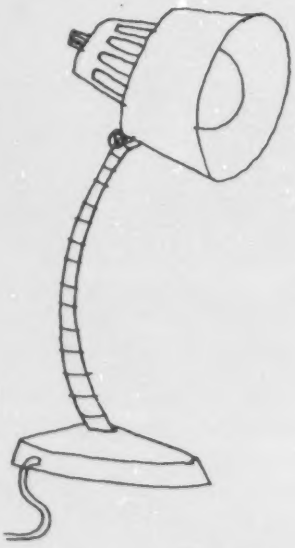
7. Trial _____ Number of Bubbles Under Colored Light

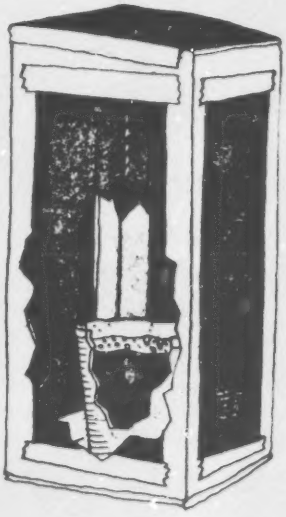
MINUTES	VIOLET	BLUE	GREEN	YELLOW	ORANGE	RED
2						
4						
6						

8. Trade your carton for one covered with a different color of cellophane from another group. Count the bubbles and record your observations in your tables. Do this with the other cellophane-covered cartons.

MATERIALS - PART B:

- Milk cartons
- Sheets of colored cellophane
- Container
- Cups filled with soil
- Dry lima beans
- Scissors
- Tape
- Water





METHOD:

1. By using cellophane-covered cartons you can see which colors of light will make growing plants healthier.
2. Soak some dry lima beans in water overnight.
3. Place three seeds in each of six cups filled with soil.
4. Place each cup in a colored cellophane-covered milk carton or box.
5. Place the box in a sunny window.
6. Water the seeds every two days.
7. Record your observations in a table like the one on the next page.

ACTIVITY 4

METHOD:

DAY	VIOLET	BLUE	GREEN	YELLOW	ORANGE	RED

GETTING IT TOGETHER:

Which colors of light did you find best for plant growth?

BACKGROUND:

When plants are photosynthesizing, the chemical that makes plants green is busy using light energy. Chlorophyll captures light going into the leaves. Chlorophyll uses the light energy to join the carbon dioxide and water together to make carbohydrates.

Sunlight is made of different colors of light. The chlorophyll seems to absorb some colors of light more than it absorbs others. Violet and blue light are absorbed the most by the leaves. Red is absorbed the least by the leaves.

ACTIVITY 5

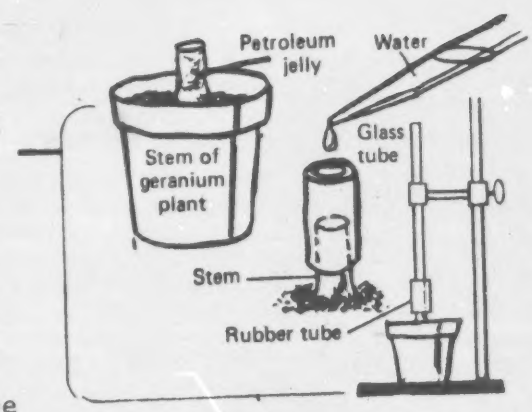
HOW DO GREEN PLANTS OBTAIN THE MATERIALS FOR PHOTOSYNTHESIS?

MATERIALS:

- Geranium plant
- Petroleum jelly
- Dropper
- Glass Tubing 10 cm
- Rubber tubing to fit stem of plant
- Ring stand and clamp
- Beaker, 100 ml
- Blue food coloring
- Celery stalk
- Knife
- Scapel
- Forceps
- Slide and cover slip
- Microscope

METHOD:

1. Cut off the top of a geranium plant about 5 cm above the soil. Spread some petroleum jelly around the sides of the stem near the top. Do not put any of the jelly on the cut end. Pull a short piece of rubber tubing down over the stem so that it fits tightly. Run a few drops of water down into the rubber tubing. This will keep the cut end of the stem moist. Wet the outside of a 10 cm piece of glass tubing. Holding the glass tube with a cloth or towel, push it into the open end of the rubber tubing. Clamp the glass tube to a stand.



*What structures of the plant are in the soil in the pot?

ACTIVITY 5

METHOD:

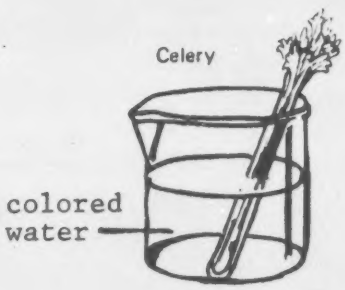
2. Examine the glass tube each day for 3 or 4 days. Make sure the soil is kept moist. You will see water in the glass tube. Mark the level of water each day with a marking pencil. Measure the height of the water above the soil, and write your observations in the table.

Height of water in tube	
1st day	cm
2nd day	cm
3rd day	cm
4th day	cm

*Where did the water in the glass tube come from?

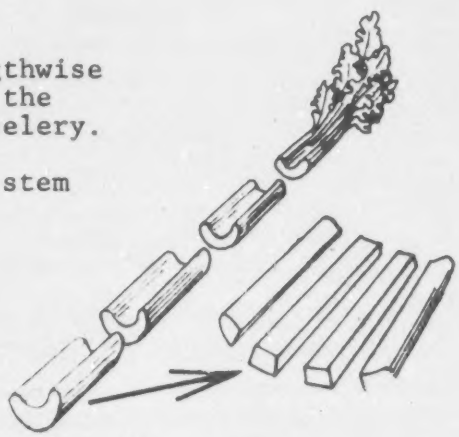
*What caused the water to move up the tube?

3. Pour 50 ml of water into a 100 ml beaker. Add 2 or 3 drops of blue food coloring, and stir. Cut the end off a stalk of celery. Place the stalk upright in the beaker. Let stand for one day. Remove the stalk from the water and cut it into four pieces. Examine the cut ends.



*What do you see that shows that water passed up the stem?

4. Cut a piece of stem lengthwise several times. Examine the sides of the strips of celery.



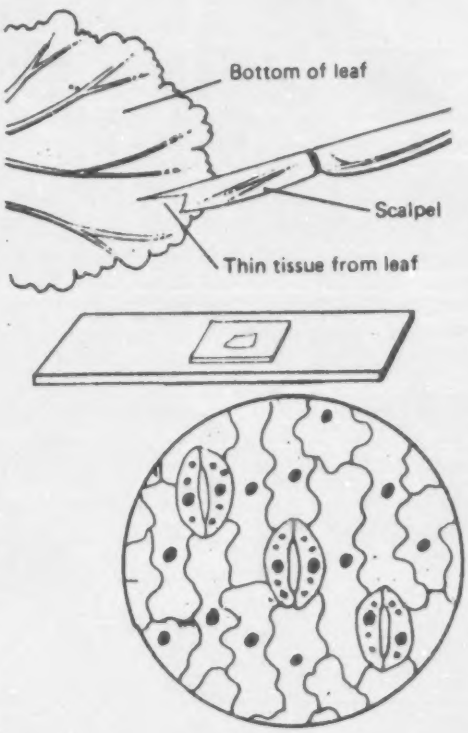
*What structures in the stem carried the water?

ACTIVITY 5

METHOD:

5. With a scalpel, carefully scrape off a thin layer of tissue from the bottom surface of a geranium leaf. Use forceps to spread a small piece of this tissue on a slide. Add a drop of water, and cover with a cover slip. Examine the tissue under the low power of a microscope. Look for a section that is only one cell thick. Examine under high power. The tissue should look like the drawing. On the drawing, label the guard cells, the stomates, and the choloroplasts in the guard cells.

   *How does the carbon dioxide in the air get into a leaf?



GETTING IT TOGETHER:

1. How do green plants obtain water for photosynthesis?

2. How does water get to the leaves of a plant?

3. How do the root cells of a plant get the food they need?

4. Why can the root cells live after the top of the plant is cut off?

ACTIVITY 6

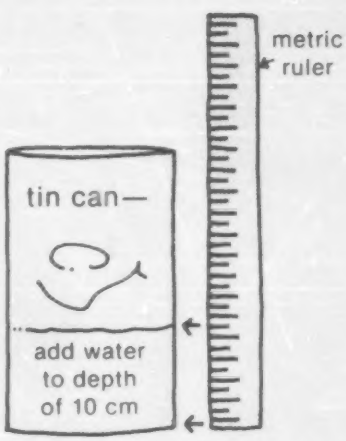
WHICH WILL GIVE MORE HEAT ENERGY: GREEN OR DRY WOOD?

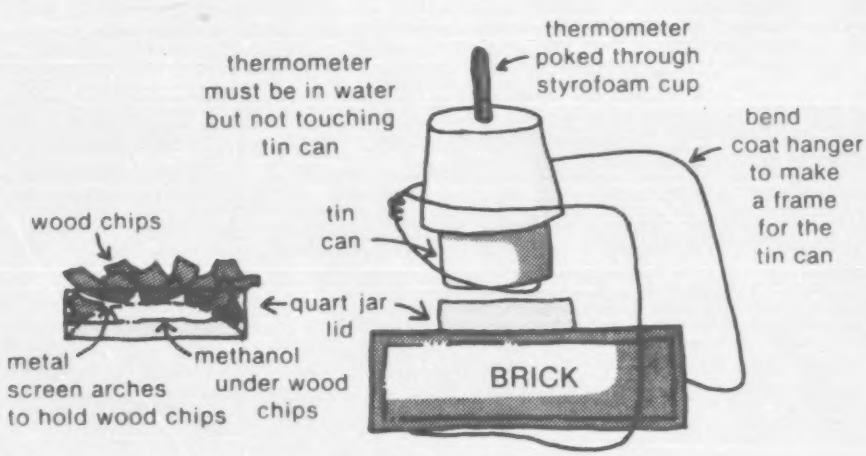
MATERIALS:

- Green and dry wood shavings (same variety)
- Methanol (hardware or paint stores)
- Large tin can; metric ruler; balance scale
- Matches; thermometer; metal screen, small piece
- Quart jar lid (remove paper liner); styrofoam cup
- Brick; eyedropper; metal coat hanger

METHOD:

1. Place quart jar lid open side up.
2. Insert a piece of metal screen in the jar lid curved up as shown.
3. Add water to a depth of 10 cm in a tin can.
4. Bend a coathanger to make a frame for the tin can.
5. Place the jar lid on a brick. Anchor the frame with the brick and suspend tin can over jar lid as shown.
6. Poke a thermometer through the bottom of a styrofoam cup and place it on top of the can. Do not let the thermometer touch the can.




thermometer must be in water but not touching tin can
thermometer poked through styrofoam cup
bend coat hanger to make a frame for the tin can
wood chips
tin can
quart jar lid
metal screen arches to hold wood chips
methanol under wood chips
BRICK

ACTIVITY 6

GETTING IT TOGETHER:

1. Measure and record the cold water temperature.
2. Add 1 eyedropper of methanol and 10 grams of dry wood chips to the jar lid and ignite.
3. Measure and record the water temperature after burning using the chart below.
4. Repeat using green wood.

	TEMPERATURE OF COLD WATER	TEMPERATURE AFTER HEATING	DIFFERENCE IN TEMPERATURES
DRY WOOD			
GREEN WOOD			

Which fuel has the most energy.

ACTIVITY 7

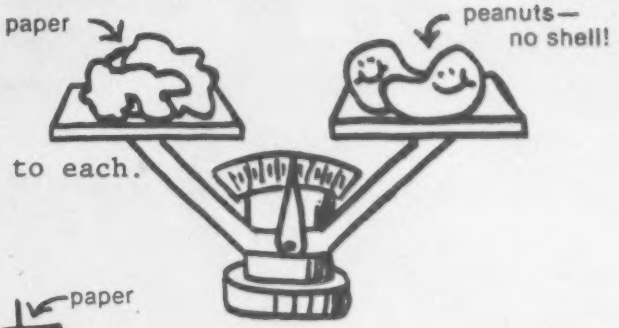
WHICH HAS MORE HEAT ENERGY: PEANUTS OR PAPER?

MATERIALS:

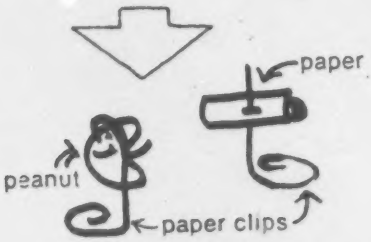
- Peanuts; paper; paper clips
- Tin can; styrofoam cup; metric measuring cup
- Wire coat hanger or ring stand; matches
- Balance scale; thermometer

METHOD:

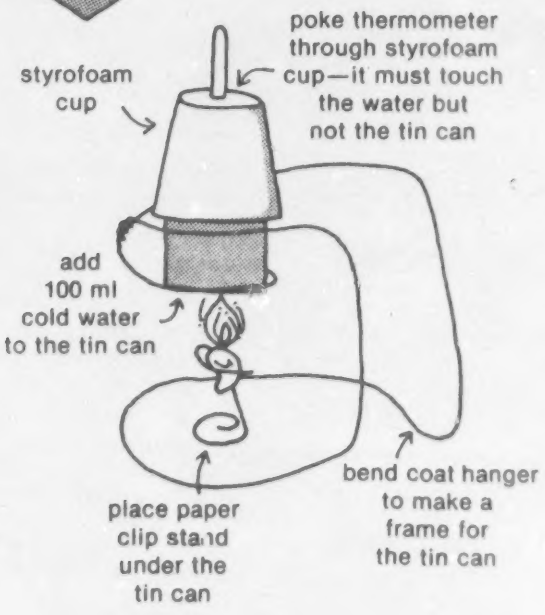
1. Weigh equal amounts of peanuts and paper.



2. Attach paper clip stands to each.



3. Set up your experiment like this.


poke thermometer through styrofoam cup—it must touch the water but not the tin can
styrofoam cup
add 100 ml cold water to the tin can
bend coat hanger to make a frame for the tin can
place paper clip stand under the tin can

ACTIVITY 7

METHOD:

4. Fill the can with 100 ml cold water. Record the temperature on the chart below.

5. Burn the paper and record the temperature of the water.

6. Burn the peanut, then record the temperature again.

		TEMPERATURE OF COLD WATER	TEMPERATURE AFTER BURNING	DIFFERENCE IN TEMPERATURE
ENERGY SOURCE				

GETTING IT TOGETHER:

1. How do you explain the results you obtained?

2. Do you think the results would be exactly the same if you did the experiment again.

ACTIVITY 8

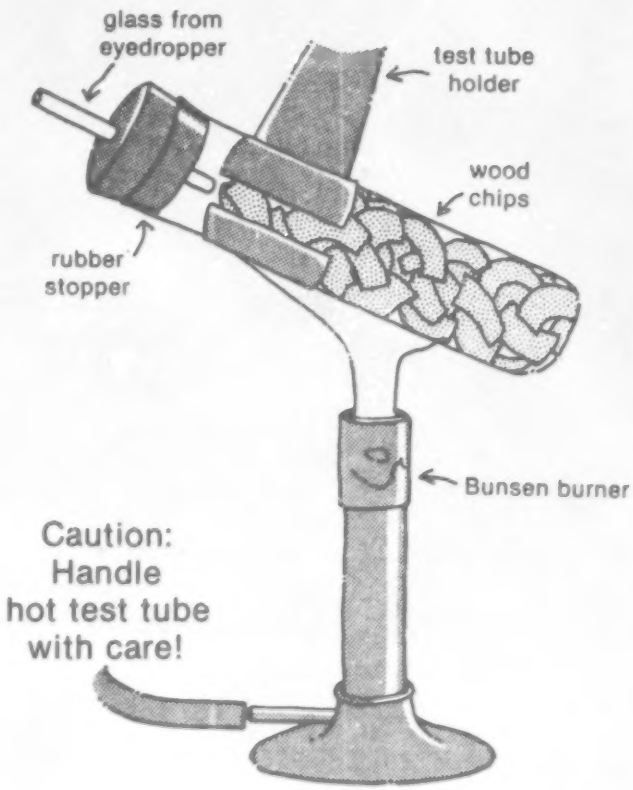
HOW LONG WILL GAS BURN THAT IS PRODUCED BY HEATING 10 GRAMS OF WOOD SPLINTS IN THE ABSENCE OF AIR?

MATERIALS:

- Wood splints or pencil shavings
- Large pyrex test tube with 1-hole rubber stopper
- Glass eyedropper; balance scale; tape
- Matches; Bensen burner
- Clock; test tube holder

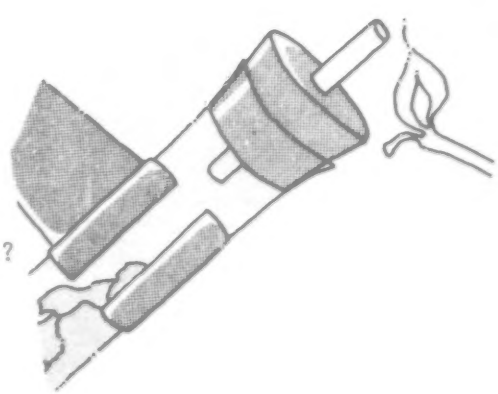
METHOD:

1. Weigh 10 grams of wood splints and place in the test tube.
2. Add the rubber stopper and the glass from the eye dropper.
3. Move the test tube through the flame. Heat the wood until you see gas escaping from the test tube.
4. Light the gas while you continue to heat the wood.
5. How long does it burn?
6. Repeat the experiment with different kinds of wood.



GETTING IT TOGETHER:

1. Weigh what remains in the test tube.
2. Has all the fuel value of the wood been used up in this process?
3. How can you find out?
4. What other substances could be used to make burnable gas?
5. Which would produce the most gas?
6. Do you think this is a good way to produce fuel? Why?



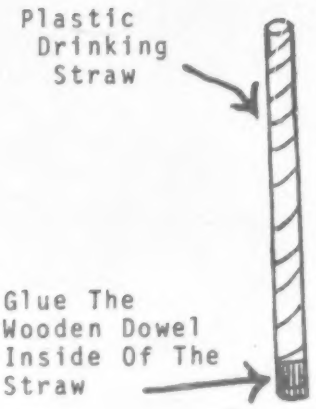
ACTIVITY 9

WHICH SOLUTION ADDED TO YEAST PRODUCES THE MOST ALCOHOL?

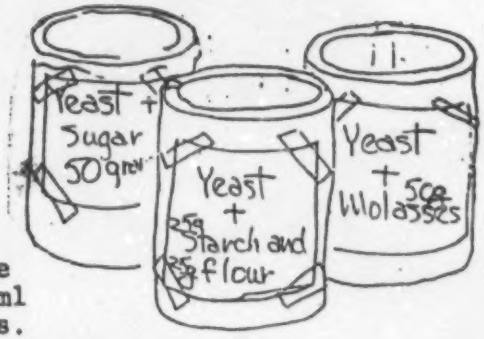
MATERIALS:

- Three (3) 1-liter thermos bottles
- Aluminum foil to cover thermos bottle tops
- Gram scale
- Metric ruler
- Celsius thermometer
- Graduated cylinder
- Plastic drinking straw
- Wooden dowel (1/4" diameter x 2.5 cm long)
- White glue
- Three (3) packs active yeast
- Warm tap water (40°C - 42°C)
- 50 grams of sugar
- 50 grams of molasses
- 25 grams of fabric starch mixed with 25 grams of white flour

MAKE A DENSITY STICK:



ACTIVITY 9



METHOD:

1. Pour 30 ml of warm tap water (40°C - 42°C) to each thermos bottle.
2. In a separate container, make a yeast paste by mixing 150 ml of water with the yeast packs.
3. Put 50 ml of yeast paste into each thermos.
4. Add sugar to one thermos, molasses to one, and fabric starch and flour mixture to the third.
5. Stir the solutions thoroughly, then measure and record their densities.
6. Make a circle with your thumb and index finger.
7. Place the density stick through the circle and into a thermos.
8. Gently balance the stick while you record the densities.
9. Use a metric ruler (cm or mm) to mark the density stick.

GETTING IT TOGETHER:

SOLUTION DENSITIES
Yeast + Sugar _____
Yeast + Molasses _____
Yeast + Starch & Flour _____

ACTIVITY 10

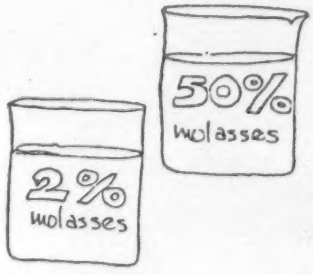
WILL A 50% MOLASSES SOLUTION PRODUCE MORE ALCOHOL THAN A 2% MOLASSES SOLUTION WHEN DIGESTED BY YEAST?

MATERIALS:

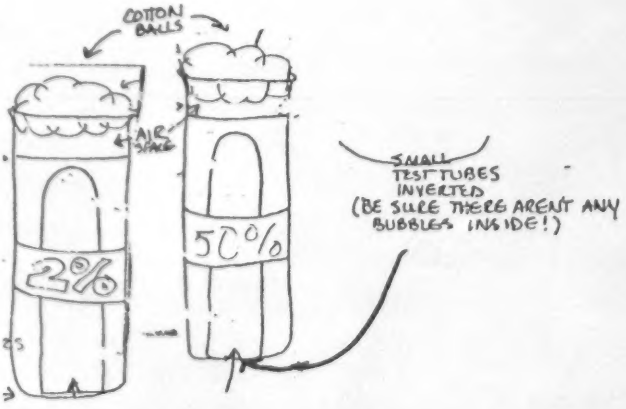
- Stock yeast solution (1000 ml of distilled water mixed with 1 tsp. of dry active yeast)
- Molasses
- Two test tubes (22 mm x 175 mm)
- Two test tubes (15 mm x 100 mm)
- Two small beakers
- Graduated cylinder
- Metric ruler
- Test tube rack
- Stirring rod
- Two cotton balls

METHOD:

1. First, make a yeast suspension - a mixture of yeast and water. In a beaker, mix 70 ml of water with 30 ml of stock yeast solution. Be sure to stir the solution thoroughly.
2. Then, prepare two molasses solutions - a 2% molasses solution (2 parts molasses to 98 parts of water) and a 50% molasses solution (50 parts of molasses to 50 parts of water).



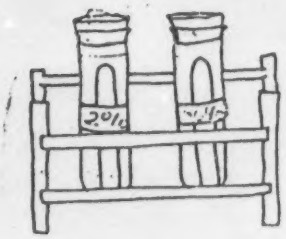
3. Fill one large test tube with 5ml of the yeast suspension and _____ml of the 2% molasses solution.
4. Fill the other large test tube with 5ml of the yeast suspension and _____ml of the 50% molasses solution.
5. Invert the small test tubes and place them inside the large test tubes.
6. Make sure there aren't any air bubbles inside the inverted test tubes.



ACTIVITY 10

METHOD:

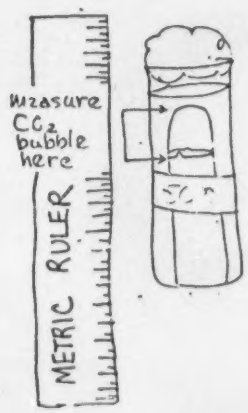
7. Set them in a warm place for 24 hours.



8. Measure the CO_2 bubbles with a metric ruler.

50% _____ 2%_____

HOW TO MEASURE A CO_2 BUBBLE



GETTING IT TOGETHER:

Did the 50% molasses solution produce twice as much alcohol as the 2% solution?

GOING FURTHER:

Would you get the same results if you used sugar, honey, or corn syrup?

What would happen if you used fructose?

UNIT VIII

MORE ENERGY ACTIVITIES

ACTIVITY 1

SUNTRAIL - SOLAR ENERGY AND THE ENVIRONMENT

DIRECTIONS:

To solve the puzzle and travel from the sun to the plant in the middle, fill in the words which complete the sentences below and fit in the numbered squares. The last letter of each word is the beginning of the next.

1. The __1__ is the source of the energy used on earth.
2. __2__ energy is released during reaction of atomic nuclei.
3. Solar energy in the form of __3__ is converted to heat when absorbed by matter.
4. Energy flows through a _____ 4 _____ like the Everglades.
5. A wheel in motion is __5__ energy.
6. The sun and electricity can produce __6__ energy.
7. Food is the source of energy for animals. Some food is used by the body to build muscle and __7__.
8. The energy that comes from electrons in motion is __8__.
9. A __9__ is about as much heat as is required to raise the temperature of one gram of water one degree Centigrade.
10. __10__ is the sum total of all living and nonliving things.
11. We all use a great deal of fossil fuel energy to get around, for __11__.
12. Large amounts of energy are released in atomic power plants because of a process of _____ 12 _____.
13. Decomposers can find __13__ in rotten logs.
14. Using the photovoltaic process, a device can convert radiant energy directly into electrical energy. This device is a _____ 14 _____.
15. The __15__ is the percentage of capacity actually utilized. Engineers in a power plant calculate the _____changes at various times.
16. Dead plants and animals are consumed by a __16__ so all matter can be recycled.
17. All plants and animals __17__ so more plants and animals populate the Earth.
18. No form of energy conversion is __18__; all lose energy to the environment.
19. A __19__ uses fossil fuel energy so people have food energy.
20. A unit of work or energy equivalent to the expenditure of one kilowatt in one hour is _____ 20 _____.

ACTIVITY 1

21. If we __21__ aluminum cans we save energy.
22. __22__ grow on trees so they can get a share of solar energy.
23. A __23__, as a vulture, serves a necessary function by using dead animals.
24. Some resources, like wood, can be produced again by growing a new supply of trees, so we say this is a _____ 24 _____.
25. The natural system in which sawgrass is a part of the energy cycle is the __25__.
26. The plant converts _____26_____ by a process called photosynthesis into plant matter.

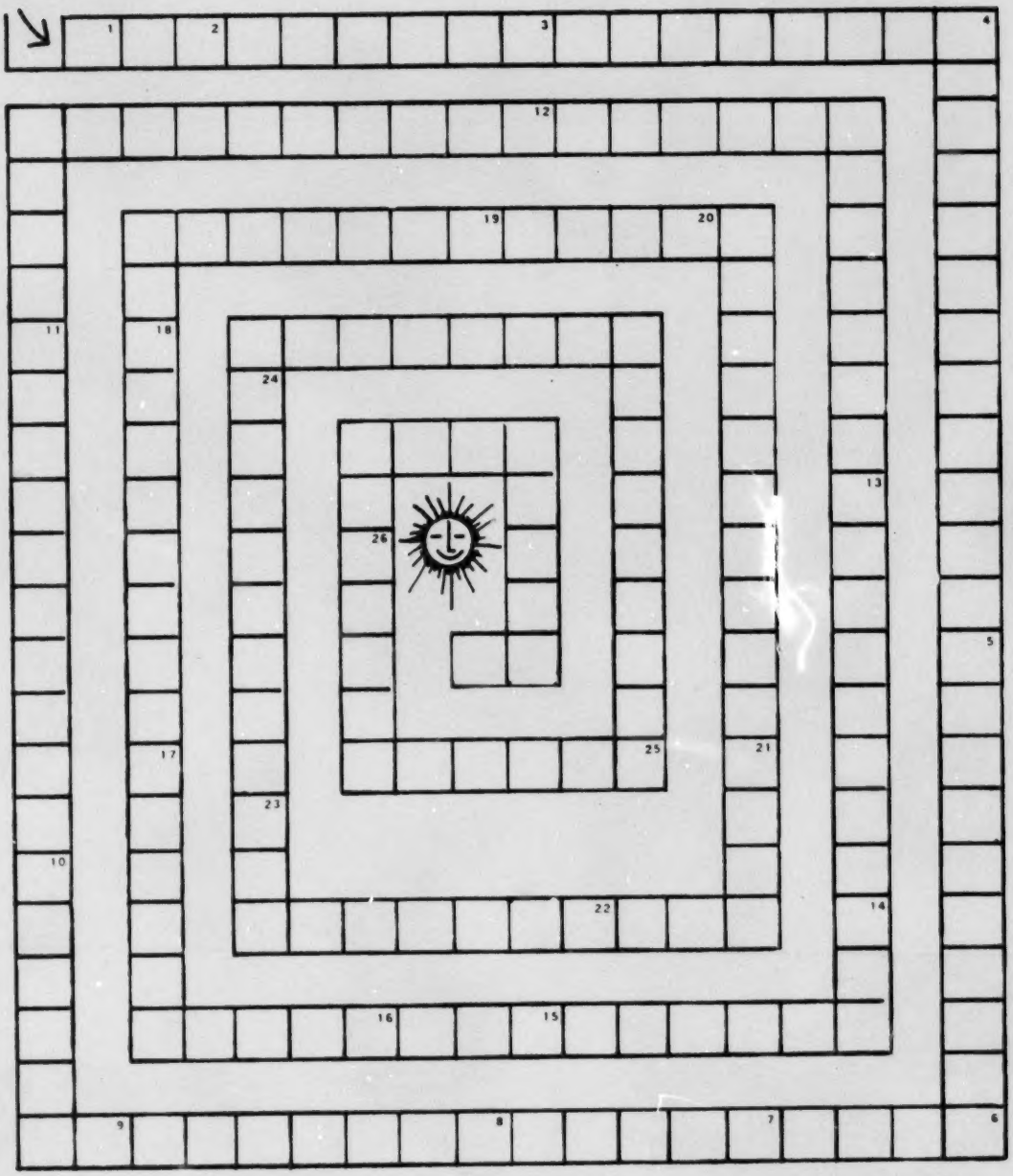
The average American used the energy from:
13.6 pounds of coal and
3.3 gallons of oil and
297 cubic feet of natural gas and
4.4 kilowatt hours of electricity
for heat, cooling, transportation, manufacturing,
generation of electricity, cooking,
plastics, paints, tv tubes, etc.

ACTIVITY 1

ANSWER SHEET FOR SUN TRAIL

1. sun
2. Nuclear
3. radiation
4. natural system
5. mechanical
6. light
7. tissue
8. electric
9. calorie
10. Environment
11. transportation
12. nuclear fission
13. nutrients
14. solar cell
15. load
16. decomposer
17. reproduce
18. efficient
19. truck
20. kilowatt hour
21. recycle
22. epiphytes
23. scavenger
24. renewable resource
25. ecological
26. light energy

SUN TRAIL



ACTIVITY 2

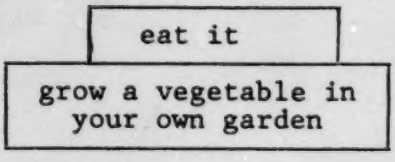
DOES IT TAKE ENERGY TO GET ENERGY?

MATERIALS:

- Pencil
- Paper

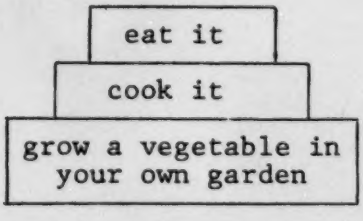
METHOD:

1. Consider the following:



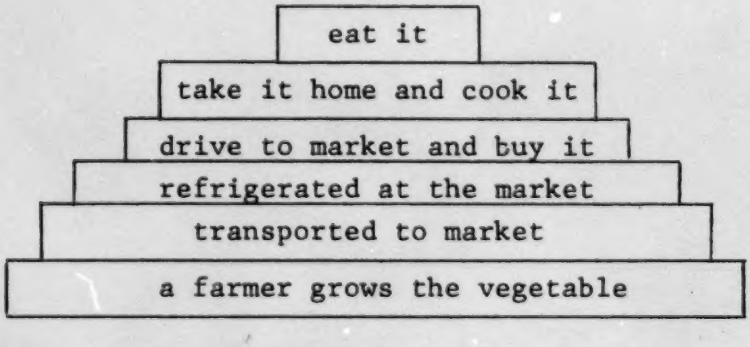
- it takes some energy to get some -

2. We could choose to:



- it takes some energy to get some -

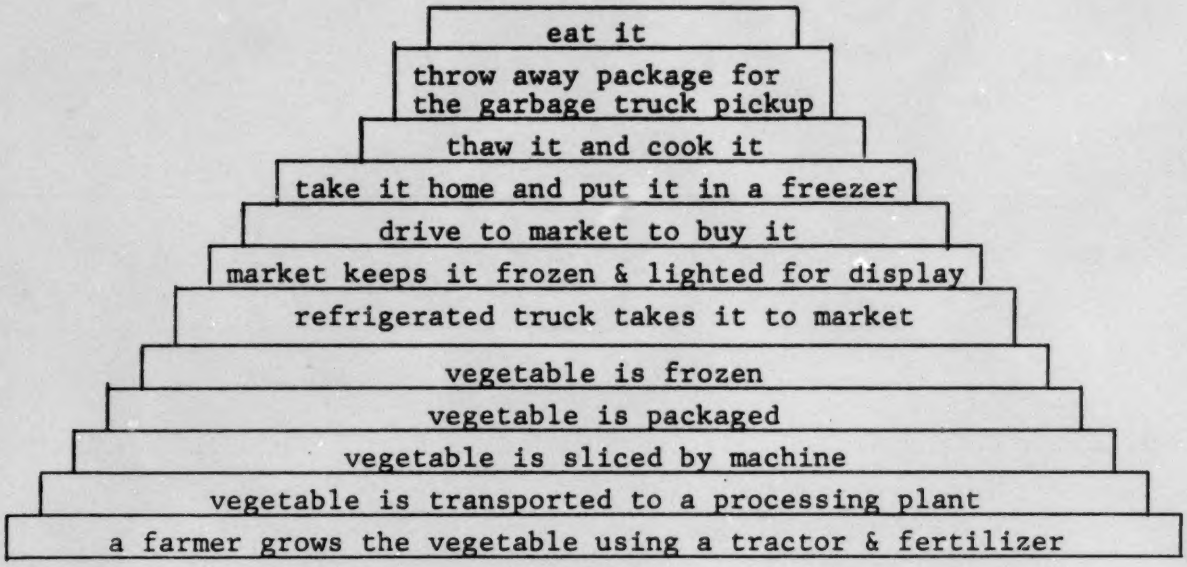
3. Going to the store adds many more steps:


eat it
take it home and cook it
drive to market and buy it
refrigerated at the market
transported to market
a farmer grows the vegetable

- it takes a whole lot more to get some -

ACTIVITY 2

4. Many products in a grocery store require all of the steps listed here:


eat it
throw away package for the garbage truck pickup
thaw it and cook it
take it home and put it in a freezer
drive to market to buy it
market keeps it frozen & lighted for display
refrigerated truck takes it to market
vegetable is frozen
vegetable is packaged
vegetable is sliced by machine
vegetable is transported to a processing plant
a farmer grows the vegetable using a tractor & fertilizer

GETTING IT TOGETHER:

Now, choose a product and build an energy pyramid taking into consideration that a city energy flow is complicated because we import energy to prepare and transport the food we eat.

ACTIVITY 3

CAN THE DOUBLING FACTOR BE DEMONSTRATED?

MATERIALS:

- Peanuts (50 for each student)

METHOD:

1. One can demonstrate the concept of depletion of a resource by giving each student 50 peanuts from a stockpile that represents a finite quantity of the resource. (Note that the number of peanuts supplied each student need not be exact. Count out one set of 50, then estimate other sets by taking comparable volumes.)
2. Then divide the class in half. To demonstrate arithmetic depletion, have half the students eat one peanut at time zero, two peanuts at 5 minutes elapsed time, three at 10 minutes, four at 15 minutes, etc. To demonstrate geometric depletion, the other half of the students should eat one peanut at time zero, two peanuts at five minutes, four at 10 minutes, eight at 15 minutes, etc. These time intervals and peanut counts work well for a 50-minute class period, but can be adjusted for periods of other length. Each time interval can represent one year or one century or any other depletion period (for geometric depletion, the time interval represents the "halving time.") Typical counts are given in Tables 1 and 2.
3. A similar demonstration, but one which involves a great deal more work, can be used to illustrate Malthus's law. Supply students with peanuts at an arithmetic growth rate, but have them consume peanuts at a geometric rate. (Start with a slight surplus and with production slightly ahead of consumption.) Typical data are given in Table 3. Many variations of the demonstration are possible. For example, one could have the peanut supply grow arithmetically, as above, and have the consumer population growing geometrically.

ACTIVITY 3

METHOD:

TABLE 1. ARITHMETIC DEPLETION

Time (Minutes)	Peanuts eaten at that time	Total peanuts gone
0	1	1
5	2	3
10	3	6
15	4	10
20	5	15
25	6	21
30	7	28
35	8	36
40	9	45
45	10	(55)

TABLE 2. GEOMETRIC DEPLETION

Time (Minutes)	Peanuts eaten at that time	Total peanuts gone
0	1	1
5	2	3
10	4	7
15	8	15
20	16	31
25	32	(63)

TABLE 3. MALTHUS'S LAW

Time (Minutes)	Peanuts supplied	Peanuts eaten	Peanuts remaining
0	(10)	1	9
5	5	2	12
10	6	4	14
15	7	8	13
20	8	16	5
25	9	(32)	-

ACTIVITY 3

GETTING IT TOGETHER:

1. Choose a non-renewable source (oil, coal, gas). Let time be years, the source be barrels, etc. Complete two tables, one using arithmetic depletion and one using geometric depletion.

2. If there are 1,000 barrels of oil left in the earth and 5,000 tons of coal, determine how many minutes it will take to use your resources.

   a. Arithmetic depletion_____

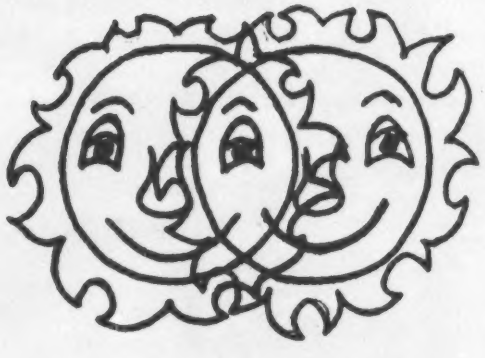
   b. Geometric depletion_____

GOING FURTHER:

1. Do you think there is an energy crisis?

2. What does this mean to the world?

3. What possible suggestions would you have to offer for improving the situation?



ACTIVITY 4

ARE THERE CAREERS IN SOLAR ENERGY?

SOLAR ENERGY CAREERS

MATERIALS:

- A notebook in which to keep career information
- The Reader's Guide to Periodical Literature
- The employment sections of large circulation newspapers, such as The New York Times or The Philadelphia Enquirer
- Periodicals (magazines)
- A word glossary
- Manufacturers' lists
- Career guidance library

ACTIVITY 4

METHOD:

1. Discuss the concept of career education with your teacher and other members of your class. Then define the term.

2. Using The Reader's Guide to Periodical Literature, and recent magazines and news articles, conduct a literature search for articles and information on solar energy jobs and careers. Also use your career guidance library to obtain additional career information on this topic. Keep a "jobs and careers" notebook containing the information you have obtained, along with any articles or information which you were able to find.

3. Search the employment sections of various newspapers for advertisements relating to solar energy jobs and careers. If possible, cut these out and place them in your notebook.

4. Using the results of your literature search and the employment ads you found, develop a list in your notebook of jobs and careers in the solar energy field. For each, determine what the job is, and what educational levels and skills are required. Both the ad itself and your career guidance library will be helpful for this.

5. Working with a partner, arrange to go out and interview someone working in the solar energy industry, such as a businessman or an installer of solar systems. Also interview representatives from state, federal, and local agencies who would be knowledgeable about jobs and careers in solar energy. Arrange for some class field trips.

GETTING IT TOGETHER:

1. Where are the best places to look for solar energy jobs and career opportunities?

2. Are there any new, unusual, or interesting job opportunities in solar energy?

3. Make a list of solar energy jobs and their requirements.

ACTIVITY 5

CAN WISE FOOD CHOICES SAVE ENERGY?

MATERIALS:

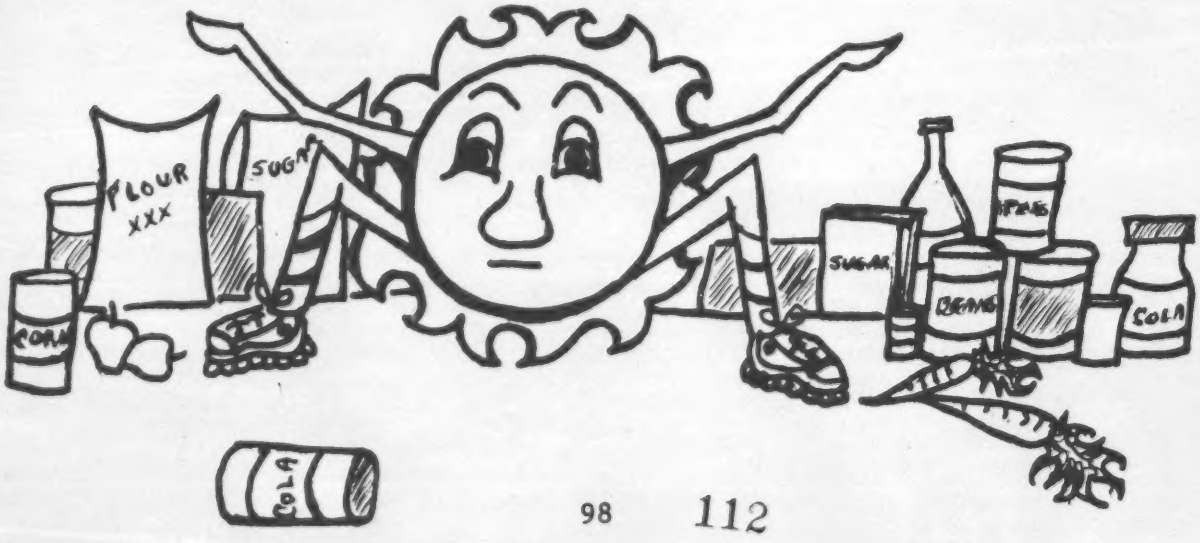
- Menu
- Pencil

METHOD:

1. Review the items offered in the menu and select your "first choices" based on your likes and dislikes. Place checks beside those items in Column 1.
2. Make selections from the menu on the basis of least energy use. Make your decisions with the following in mind: The energy cost of a food includes things like fertilizers, insecticides, equipment, feeds, transportation, processing, packaging, advertising, and preparation. Place a check by each low energy item in Column 2.
3. Now refer to the Energy Price List for each item's energy cost. Show the "price" of each item you chose and determine your total bill.

GETTING IT TOGETHER:

1. Discover how much energy you could have saved by finding the difference between the individual items in the two columns and enter those figures in Column 3. Add the total "pluses and minuses" in this column to find total energy savings.
2. If you were to select items for Column 1 (choices) again, would your choices be any different?



ACTIVITY
5

WORKSHEET

APPETIZERS (Choose one juice, one cracker & butter or margarine)	Column 1	Column 2	Column 3
Fresh Orange Juice	___ _____	___ _____	_____
Frozen Orange Juice	___ _____	___ _____	_____
Cracker A	___ _____	___ _____	_____
Cracker B-wrapped individually	___ _____	___ _____	_____
Butter	___ _____	___ _____	_____
Margarine	___ _____	___ _____	_____
MAIN DISH (Please make a First & Second choice as we do not always carry each entree)			
Luncheon Meat	___ _____	___ _____	_____
Chicken	___ _____	___ _____	_____
Turkey	___ _____	___ _____	_____
Rice with Vegetables	___ _____	___ _____	_____
Beef (grass-fed)	___ _____	___ _____	_____
Beef (grain-fed)	___ _____	___ _____	_____
VEGETABLE (Sorry, today we have only carrots, but you may choose your preferred type.)			
Fresh Carrots	___ _____	___ _____	_____
Dehydrated Carrots	___ _____	___ _____	_____
Frozen Carrots	___ _____	___ _____	_____
Canned Carrots	___ _____	___ _____	_____
DRINKS (Please choose a First & Second choice as we sometimes run short of one kind of drink at lunch)			
Soft Drink (in aluminum can)	___ _____	___ _____	_____
Soft Drink (in returnable glass bottle)	___ _____	___ _____	_____
Milk	___ _____	___ _____	_____
Beer (in aluminum can)	___ _____	___ _____	_____
Beer (in returnable glass bottle)	___ _____	___ _____	_____
DESSERT (Choose one)			
Apples (Homegrown in our cafeteria's own garden)	___ _____	___ _____	_____
Apples (store-bought)	___ _____	___ _____	_____
Walnuts (shelled)	___ _____	___ _____	_____
Walnuts (unshelled)	___ _____	___ _____	_____
Ice Cream	___ _____	___ _____	_____
TOTAL BILL	_____	_____	_____

ENERGY PRICES

(Prices are proportional to actual energy expenditure)

APPETIZERS	Cents
Fresh Orange Juice	.12
Frozen Orange Juice	.46
(Freezing and processing use a great deal of energy, both initially and for storage.)	
Cracker A	.10
Cracker B (individually wrapped)	.15
(Food excessively packaged or only available in small packages is more energy-intensive than wrapped foods or foods available in bulk.)	
Butter	.15
Margarine	.05
MAIN DISH	
Luncheon Meat	$1.60
Chicken	.96
Turkey	1.06
Rice with Vegetables	.45
Beef (grass-fed)	1.48
Beef (grain-fed)	2.08
(Animals are inefficient converters of protein. A pound of meat requires about four times the energy to produce and market as a pound of vegetable protein. Some animals are more efficient converters of protein than others.)	
VEGETABLE	
Fresh Carrots	.12
Dehydrated Carrots	.92
Frozen Carrots	.31
Canned Carrots	.23
(Processed vegetables require more energy than fresh vegetables; freezing and dehydration especially require large amounts of energy.)	
DRINKS	
Soft Drink (aluminum can)	.45
Soft Drink (returnable bottle)	.31
Milk	.34
Beer (aluminum can)	.50
Beer (returnable bottle)	.25
DESSERT	
Homegrown apple	.03
Store-bought apple	.19
(Homegrown apple by commercial methods saves commerce and transport; organic methods would save more.)	
Walnuts (shelled)	$1.04
Walnuts (unshelled)	.39
Ice Cream	.60
(Large quantities of milk used; freezing is necessary.)	